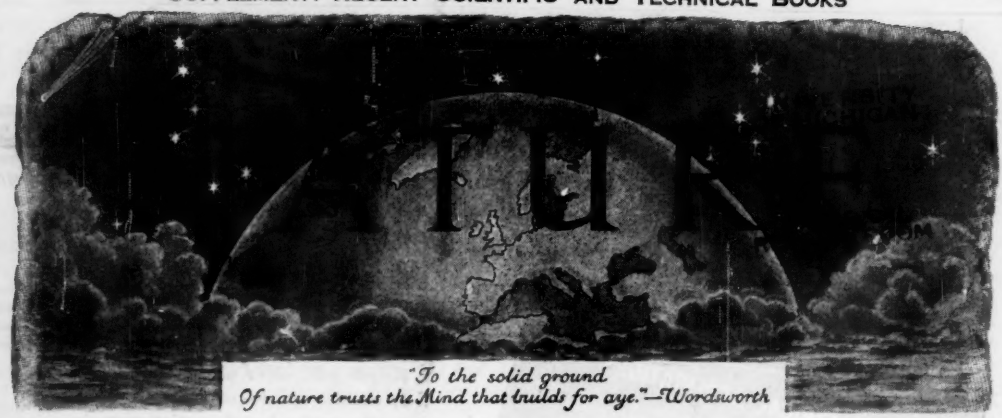


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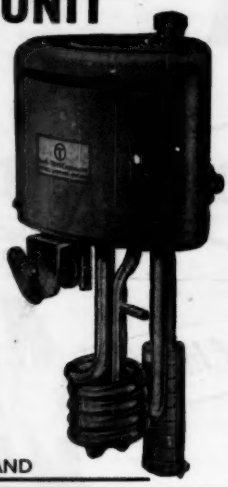

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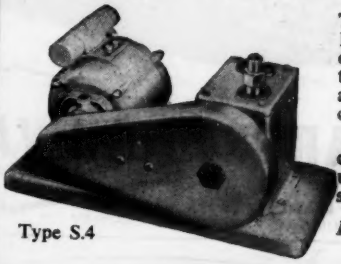

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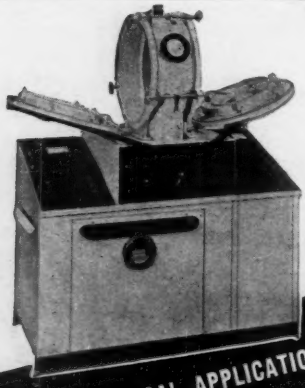

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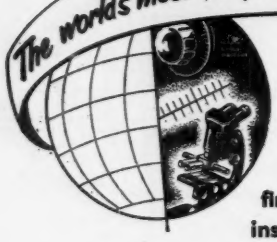

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# NATURE

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# SUPPLY OF SCIENCE AND MATHEMATICS TEACHERS

SOME of the general implications of the report of the Appleton Committee on the Supply of Teachers of Mathematics and Science in Scotland have already been discussed in these columns (*Nature*, June 18, p. 1051). Apart from these general recommendations, the report includes a number of detailed comments and suggestions for dealing with the specific problem it was set up to consider.

Among these recommendations is one dealing with salaries. The report does not underestimate the importance of the question of salaries as affecting the number of specialist teachers of mathematics and science. It thinks that excessive competition with industry would be inexpedient and even harmful; though it considers that specialist teachers have some cause for discontent when they see others, with equivalent qualifications, earning much higher salaries. It is the lower maxima that are the real problem: at the start the specialist teacher is paid as well as, or better than, his colleague in industry or the Scientific Civil Service.

For these reasons, and to ensure that teaching continues to attract some of the best honours graduates, the Appleton Committee recommends increasing the basic maximum for men specialists from the present figure of £960 to £1,150 per annum, with corresponding changes in the women's scales. It does not recommend reduction of the present period covering the increase from minimum to maximum, but comments on the length of this period and the small increments. It also recommends an increase in the special allowance to sub-specialist teachers of mathematics and science to £95 in place of the present £25 per annum. It considers that rather too much stress is laid at all stages of the teacher's career on initial qualifications. It is thus difficult for a man, however distinguished his teaching service, to surmount any shortcomings in his original qualifications; and there are also areas in Scotland where promotion is based excessively on seniority. Also, the highest promotions in the profession take the teacher away from active teaching. It is undesirable, in present circumstances, that a highly qualified person should give up advanced class-work mathematics or science for a minor post of responsibility in a junior secondary school; and the Committee recommends, therefore, the institution of a new post, that of senior assistant, for teachers, not principal teachers but those who are doing advanced work in senior schools, and that these teachers should receive additional salary to compensate them for loss of the responsibility payments that they might have expected to receive had they transferred to junior secondary schools. The Committee found no substance in the representation that, because of the tradition and prestige of classics, teachers of mathematics and science receive less than their due share of available promotions. The lack of laboratory assistants, it considers, has also been over-stressed as a deterrent to recruitment, though in larger schools employment of a laboratory assistant may be desirable, and in the critical period immediately ahead of us more use must be made of less highly qualified persons.

It is likewise essential that there should be no waste of highly skilled man-power outside the teaching profession, and the report thus endorses the action already taken by the Government to ensure the most economic use of scientific man-power in all branches of the national life. Two specific recommendations are made by the Committee for the use and up-grading of third-class honours graduates in mathematics and science in teaching. It also recommends amendment of the regulations for the training of teachers so that teachers are specially trained to teach modified classes in junior secondary schools in place of the sub-specialist teachers at present used, and also so that the sub-specialist qualification becomes a principal qualification for secondary work.

These long-term remedies should stimulate recruitment, so that the supply of mathematics and science teachers should become more adequate from the middle 'sixties. To alleviate the grave shortage during the next ten years, the Appleton Committee recommends measures to ensure the fullest use of personnel in the schools. Dilution must be carried much further along the lines already indicated, and the fullest possible use made of retired teachers. It is improbable that the number of retired specialist and sub-specialist teachers of mathematics and science under the age of seventy who could be obtained would at any time exceed 200; but even so, their help would be invaluable. The Committee thus recommends that while the period of shortage continues, mathematics or science teachers continuing in or returning to service between the ages of sixty-five and seventy should receive the full salary for their post together with full pension. If this proposal is unacceptable, the Committee makes two minor proposals to remove the discouragement to continued service which present pension regulations offer. It also comments on the absence of benefits for widows and dependants of deceased teachers, and the desirability of utilizing part-time services where available. After weighing carefully the divergent views on teacher training, it recommends no reduction in the length of training courses for specialist teachers of mathematics and science, but that allowances, independent of parental income, should be given during this training year which would cover fees and some £250 of maintenance expenditure. Further, on National Service the Committee reached an early conclusion that graduates with first- or second-class honours in mathematics and/or science who had undergone a course of teacher training should be deferred from national service while the present acute shortage of such persons continues, and as long as they are prepared to teach their subject in the schools.

This proposal goes appreciably further than that recommended by the Federation of British Indus-

tries and is fairer both to the schools and to the Armed Forces. A letter to this effect was sent by Sir Edward Appleton to the Secretary of State for Scotland in May 1954. The step was taken with some reluctance, and the Committee made it not in the interests of education *per se* but in the wider national interests; the position is completely without parallel among teachers of other subjects, but indefinite deferment should not be continued longer than the situation demands.

As already noted, the Appleton Committee firmly rejects the idea of less science teaching in the schools. It does not believe that school laboratories in general are as unsatisfactory as to defer the recruitment of science teachers, or that there are real obstacles to the use of women part-time teachers. It is doubtful, however, whether any appreciable part-time assistance is available from industry or the universities, even if the difficult salary questions could be overcome, nor does it favour the idea of compressing university courses.

Of the repercussions of these proposals the economic effects are probably the least important. To give the recommended increase in salaries to all specialist teachers of mathematics and science would cost about £120,000 in Scotland; to give it to all specialist teachers in Britain would cost some £600,000, and the proposals for sub-specialists would cost another £400,000 if applied to all sub-specialists. On the basis of the figures for the shortage given by the Federation of British Industries' Committee, the proposals of the Appleton Committee might cost some three or four million pounds if applied to the whole of Britain.

This is not an expenditure lightly to be incurred; but on the evidence presented in the Appleton report, it is a small sum to pay to remove a serious danger to the national interest. The difficulty lies rather in determining how best it can be provided without undesirable repercussions, such as weakening local government. It may well be that, as Dr. B. V. Bowden, principal of the Manchester College of Technology, pointed out in a forthright presidential address to the North-Western Branch of the Science Masters' Association last November, the payment of schoolmasters' salaries from the rates is an archaic means of taxation. Local interest in and responsibility for education are not archaic; they are an essential condition of a live democracy, and the real financial problem is to remove anomalies and disparities and to raise standards without impairing local interest and responsibility.

Dr. Bowden's address has received nothing like the attention it deserves. Many of his points are indeed also made by the Appleton Committee; but his address provides illustrations which emphasize those points, and his comments are sometimes more trenchant than could be expected from a Government-constituted committee. He puts, for example, the cost of the Federation of British Industries' Committee's proposal in its right perspective against expenditure on university education in general; he does not hesitate to point out that if the additional money is to be found, it will be at the expense of other social services like housing, and he condemns the preposterous egalitarianism which has been forced on the teaching profession by its non-graduate members. Nor does he fail to remind science masters that a part of the remedy lies in their own hands: the most generous salary scales will not attract recruits of high quality unless science masters themselves have a high ideal of their calling, and can convey some of their respect for their calling to some of their pupils.

These are not points that either political party has been honest or courageous enough to face or to tell the public; but they need making. Disregard of them will frustrate any attempt to deal with a shortage which threatens to endanger the whole educational system of Britain and with it our industrial and economic life. Dr. Bowden argues, indeed, that science teaching at present depends to an alarming extent upon the loyalty of members of the staff who were appointed before the War. These men are not being replaced, and when they are gone the whole of our educational system may collapse completely. Without science masters there will be no science teaching, and without science teaching the universities and technical colleges will not receive competent students; and ultimately industry will be deprived of its supply of trained engineers, scientists and technologists and be brought to a grinding halt.

Dr. Bowden points out more clearly than some other participants in this discussion that this extreme shortage of science teachers has persisted since 1939, and that its continuance for another fifteen years could bring science teaching in Britain to an end. Moreover, this numerical conspectus takes no account of the fact that the teaching of science in our sixth forms before the War was the best in the world, as well as the basis of all our university work, or of the influence of the science master in turning the thoughts of his pupils towards a career in science or technology. In default of that influence, moreover, whatever steps may be taken to facilitate transfer from the arts to the science either at the sixth-form stage or in the university are likely to fail of their full effect.

What stands out from Dr. Bowden's address and from the report of the Appleton Committee is not so much the urgency of the problem as the need for imagination and courage in dealing with it. Administrative convenience could well wreck our whole economy if it is allowed to hinder official recognition that good science teachers are more valuable to that economy than any of their colleagues. The pursuit of false egalitarianism in the teaching profession or in politics could be equally fatal, for besides adjustment of the salary scales as recommended in these reports, the question of quality is all-important. It is the vision and character of the science teacher that will be the decisive factors in encouraging more students to take up a career in science and technology, just as his competence as a teacher plays a large part in developing their latent ability to its full extent. It is from the science master in the first instance that the student is likely to glimpse the fascination of science and technology as living and growing subjects, and the varied opportunities of a

satisfying career which they offer. If science teaching is to find an honourable place among those opportunities and attract young students to such a career, it will largely be in such measure as the student glimpses in his science master the sense of satisfaction in a high vocation, in the service of worthy ideals which are at least as important to a full life as monetary rewards. To deal effectively with the shortage of science teachers demands both long-term and short-term measures. It may well involve fresh thinking about general education and the standards of university entrance—even about the purpose of university education and of secondary education. First and foremost, however, it demands giving honour where honour is due, that is, according the science teacher the place in the public esteem that the nature and importance of his work demand and treating him accordingly. Of the teacher it demands that he shows himself worthy of that esteem and allows no false ideas of egalitarianism to lead him to forsake the traditions and standards that, as Dr. Bowden reminds us, made the educational standards in our sixth-forms the best in the world.

## WHO'S WHO IN AMERICAN SCIENCE

### American Men of Science

A Biographical Directory. Edited by Jaques Cattell. Ninth edition. Vol. 1: Physical Sciences. Pp. v+2180. (Lancaster, Pa.: Science Press; New York: R. R. Bowker Company, 1955.) 20 dollars.

ONE of the phenomena of the twentieth century has been the enormous expansion in scientific and technological effort throughout the world, and in no country has this been more marked than in the United States. An indication of this expansion can be gauged from the fact that in 1900 the first edition of "American Men of Science" contained four thousand names, the eighth (1944) some fifty thousand, and the ninth, of which this is the first of three volumes, will have an estimated ninety thousand entries. Of course, it can be argued that the sizes of the various editions may not be proportional to the country's scientific effort, since a compiler can be more (or less) selective in preparing a new edition. Nevertheless, a noteworthy feature of "American Men of Science" is that, since its inception, it has been in the hands of but two editors, and these are father and son: J. M. Cattell was the original editor, and the present work is the responsibility of Jaques Cattell. Thus throughout the lifetime of this work the editorial policy is not likely to have suffered any abrupt changes, and it can be fairly deduced that the growth of "American Men of Science" does, in fact, measure the growth of North American science (Canadian workers are included).

A glance at the editor's preface of the present volume reveals some of the difficulties that had to be faced in compiling the new edition. In the planning stage it was estimated that eighty thousand names would need to be entered, and so it was decided to break the work up into three volumes, on the physical sciences (the present volume), biological sciences and social sciences, respectively. In fact, this was an underestimate, for the original calculation of thirty-five thousand names for Vol. 1 has turned out in practice to be 43,518, and the total is expected to run to more than ninety thousand. Now that the work is split into three parts, a new problem arises as to which volume a borderline scientist belongs; in particular, this problem arises between Vols. 1 and 2, when dealing with biochemists and biophysicists. In each such case the individual concerned was given the choice of which volume he preferred to appear in, and for most of them a "see reference" has been inserted in the other volume. One cannot help feeling that this has led to a great deal of extra work and complication, all of which could have been obviated if the three volumes had simply covered all the names in alphabetical order. From the user's point of view, if one knows nothing about a scientist except his name, he may be in any of the three volumes. The principal advantage seems to be that those who are interested in but one branch of science need only buy one of the volumes; but for a work of reference such as this, it is far more likely that purchasers will want all three.

Of the other changes for this ninth edition, one that immediately strikes the eye is that an offset printing process has been used throughout, and consequently the lines are not of uniform length. This gives a rather untidy appearance; but it does not diminish the value of the content, and there may well have been over-riding technical and/or economic reasons for choosing this method of printing. A less obvious change is that the former practice of allotting asterisks to a select few who are judged to be outstanding in a particular science has been abandoned. This is a change for the good; there must always be some difficulty (and misjudgment, too) when deciding whether or not to include a particular name in the work, but to attempt to classify those already in as 'ordinary' and 'extraordinary' seems to be making an unnecessary and invidious distinction which an editor would be well advised to eschew. A feature of the work that is to be commended is that Christian names are given in full and all but the first letter are bracketed off in those cases where the bearer wishes to be known by an initial. This is particularly suited to American conditions, since in the New World many people prefer to use their Christian names (and often not the first one) in conjunction with their surnames.

In general, this is a work of reference that has a definite place as the "Who's Who" of North American science. As with all such books, it may contain a few names that scarcely deserve the honour, and almost certainly there must be more than a few scientific workers who are not listed but who could with justice be given an entry. Nevertheless, the work has stood the test of time, and this volume is worthy of the tradition established by the previous editions.

## METAPHYSICS RECONSTRUCTED

### The Metaphysics of Logical Positivism

By Gustav Bergmann. Pp. x+341. (London: Longmans, Green and Co., Ltd., 1954.) 42*s*. net.

THIS book consists of a selection of essays which the author has contributed to various philosophical journals over the course of several years. They have not been re-cast, and perhaps on that account are the more valuable as showing the development of an active mind as it battles with the

changes in a somewhat fickle intellectual climate. As the title would indicate, much of what is said rests upon the basic researches in Britain of Moore, Russell and Wittgenstein. We are presented with a well-balanced account of what logical positivism is—and always has been—coupled with a just assessment of the differences of emphasis between the disciples of the Vienna Circle and the rest of the world.

The drift of the writer's thought, as he takes a very wide sweep around his subject, tends (perhaps unavoidably) to obscure the relations, often rather strained, between logical positivism and metaphysics which, after all, are what he is engaged in discussing. Logical analysis is assuredly held to be a reasonable concept of philosophy, and its study involves a close scrutiny of language as we normally use it as a rough-and-ready means of receiving and imparting information. In a limited sense, and apparently only with respect to traditional forms, metaphysics is rejected. This, if I understand the thesis aright, is a rather more liberal position than usual. In the chapter on reconstruction, we find the remark that an "unexamined metaphysics" is the worst of all. This seems to suggest that there may be systems in themselves capable at least of investigation which would not come under the lash. This is very near the plea advanced a few years ago in quite another context that metaphysics must be adaptable and sympathetic to development if it is to be taken seriously as a true *scientia*. Most people would readily agree.

Meanwhile, mankind has become aware—and during recent years maybe increasingly aware—that there are 'events' (as Whitehead might have said) which can be both apprehended and measured, and those which can be apprehended but not measured. This distinction, made explicit many years ago, is perhaps the operative link between the exact sciences and those like æsthetics and sociology which receive attention towards the end of this volume. There can be little doubt that metaphysics, as a distinct subject of study, is called upon to do much more than "to save appearances" if it is to save itself and the great service which it has been able to render to scholarship through the ages.

Philosophy's task is above all to recognize problems as problems, and to evolve a language suitable for their precise formulation. F. I. G. Rawlins

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### Non-Ferrous Foundry Metallurgy

The Science of Melting and Casting Non-Ferrous Metals and Alloys. Edited by Prof. A. J. Murphy. Pp. x+498. (London: Pergamon Press, Ltd., 1954.) 70*s*. net.

As with many other branches of production metallurgy, foundry work developed during the centuries as a craft and then only quite recently as a technology based on an understanding of the underlying scientific principles. Indeed, the scientific study of foundry problems has been made mainly during the past twenty or thirty years, and foundries still exist which depend for their existence upon the experience and skill of their foundrymen, rather than upon the application of scientific knowledge. The industry as a whole, however, is now alive to the value of the scientific approach to technical problems and will welcome this book, to which a number of well-known foundry metallurgists have contributed.

The book is logically arranged. Approximately the first third is devoted to a scientific treatment of liquid metals, gases in metals and solidification. These chapters are well written and form a sound basis on which the rest of the book is built and on which the reader may reasonably expect to attempt a solution of his own foundry problems.

By contrast, in the long chapter on non-ferrous foundry technology the emphasis is upon practical details rather than on principles. The authors seem to regard their treatment as sufficient in itself; but some readers are likely to feel the need for amplification of certain points and will regret that references to other sources have not been included. It can scarcely be claimed that the section on ingot casting is comprehensive, and yet there is not a single reference to another work on the subject. Nor, in a chapter avowedly on technology, would one expect to find the shell-moulding process dismissed in a short paragraph; there is considerable interest in this essentially post-war development, and a much fuller account would have been justified.

The factors that influence the properties of castings are discussed in some detail in the next section, which also includes an authoritative account of the various methods of measuring the gas content of cast metals and a review of non-destructive testing. Most of the latter is concerned with radiographic examination, and there is only brief reference to ultrasonic and other methods.

In the final and longest section, seven well-known metallurgists discuss the foundry characteristics of the principal casting alloys classified according to their respective basis metals. The information provided is based on practical experience as well as on an appreciation of the scientific aspects. It should prove particularly useful to those who have occasion to make castings in alloys hitherto outside their experience.

Taken as a whole, the book is a useful addition to the literature on foundry metallurgy and deals with all aspects of non-ferrous practice. The foundry industry will benefit if the book is widely read by its metallurgists. There will certainly be other editions, and it may not be out of place to suggest that in future the names of the contributors should appear on the table of contents so that readers can more easily find out who has written what they are reading.

A. G. Quarrell

## CHEMICAL ASPECTS OF ATOMIC ENERGY

### The Actinide Elements

Edited by Glenn T. Seaborg and Joseph J. Katz. (National Nuclear Energy Series: Manhattan Project Technical Section. Division 4—Plutonium Project Record: Vol. 14A.) Pp. xxx+870. (London: McGraw-Hill Publishing Company, Ltd., 1954.) 94*s*.

This volume of the National Nuclear Energy Series is a companion to the earlier "Transuranium Elements"; but whereas that was a collection of research papers, the present book is a series of reviews by experts and maintains a high standard of writing throughout, giving a much more balanced and useful account of the chemistry of the

heavy elements so far as the general reader is concerned.

With the development of a large-scale nuclear power programme, a considerable chemical industry will also arise to fabricate and reprocess the fuel elements, and some knowledge of the chemistry of the heavy elements is necessary to an understanding of the basis of this industry which must gradually involve more and more chemists and chemical engineers from outside the official projects. To the student and teacher of chemistry, there is also much of interest, since many advances in inorganic chemistry have been made in this field. Moreover, research which has for a decade been largely conducted in the secrecy of government laboratories is once more being pursued in universities, now that the basic chemistry is being freely published in journals and books.

The chapters may be divided into categories. First there are those appealing mainly to a radiochemist, such as five dealing with the nuclear properties of all the isotopes of the elements from thorium to californium, and two on radiochemical techniques which give very full and authoritative accounts of separation methods and of alpha and fission counting respectively. There is then a group of chapters reviewing the basic chemistry, element by element, from actinium to the transplutonium elements taken together. Each chapter is sufficiently complete to be used as a general source without becoming a mere catalogue. The chemistry of plutonium, as befits an element of strategic and economic importance, is covered in three chapters. That on oxidation-reduction reactions and equilibria in solution contributes a great deal to clarify a very complex situation arising from the possibility of four valency-states co-existing in solution. Equally important is the chapter on ionic and molecular species in solution, where complex-ion formation has striking effects. Finally, there is an exhaustive dictionary of plutonium compounds, giving preparation and properties.

There are two rather specialized chapters reviewing the crystal structure and optical properties of compounds of the actinides, and one of the final chapters discusses the correlation of the chemical, spectroscopic, magnetic and crystallographic evidence, with respect to electronic structure and place in the periodic table; a very strong case for an actinide transition series is made out, although this is to-day a controversial point only for gaseous atoms.

The book is very well produced and remarkably free from misprints and errors, but rather expensive for the general reader. R. HURST

## PROTEIN STRUCTURE AND METABOLISM

### Serological Approaches to Studies of Protein Structure and Metabolism

Edited by William H. Cole. (Rutgers University: Bureau of Biological Research Annual Conferences on Protein Metabolism.) Pp. xi+97. (New Brunswick: Rutgers University Press, 1954.) 2 dollars.

POSSIBLY someone who is interested in protein structure and metabolism and is not soaked in serology would be better equipped than I to review this book. He might be better able to judge how far the book indicates the possible applications of serology and warns of the difficulties and limitations.

Heidelberger gives an outline of the quantitative methods that have been used in much of his work and have, together with Landsteiner's work with artificial antigens, formed the basis of most of our theories about antibodies and their reactions. Gitlin and Boyden describe techniques that may be very useful in quantitative work. I have only one small criticism of Munoz's excellent review of the gel diffusion method: he does not mention the great value of Ouchterlony's method of distinguishing cross-reactions between two preparations, due to two similar but not identical antigens (such as hen and duck ovalbumin), from cross-reactions, due to the presence of a common antigen.

Cohn describes an exciting application of serology. In the presence of a number of β-galactosides, *Bacillus coli* forms β-galactosidase (Gz), which is a good antigen. In the absence of a β-galactoside, another protein (Pz) which is not antigenic is formed. Pz forms a precipitate with antiserum against β-galactosidase, but when the two compete the latter is precipitated preferentially; both can be measured in mixtures of the two. All species of Enterobacteriacae that form the same β-galactosidase, or are capable of a mutant that does, contain Pz; those that are never known to form β-galactosidase do not. The formation of β-galactosidase in the presence of a β-galactoside leads to a decrease in the rate of formation of Pz; but the latter is not a precursor of β-galactosidase. There is no evidence of a dynamic equilibrium between β-galactosidase and other proteins.

Gitlin describes quantitative experiments that show that the serum albumin, in cases of nephrosis, and urinary albumin are serologically identical with normal serum albumin, and that in a-gammaglobulinæmia and a fibrinogenæmia the rates of synthesis of γ-globulin and fibrinogen are reduced. Boyden describes the application of a quantitative method to the correlation of the serological and the taxonomic relationships of animals.

Haurowitz finds that the labels of certain labelled proteins survive, apparently attached to protein, in cytoplasmic granules of reticuloendothelial cells of liver and spleen, and concludes that antibodies are made in these granules.

Now, I must turn to the difficulties and traps. There is no suggestion in the book that it may be difficult to get satisfactory antisera against some antigens—hæmoglobins, for example. There are indications in the articles on gel diffusion and on serological correspondence that considerable amounts of antibody may be formed against impurities of the antigen used for immunization. These antibodies have led to errors in attempts to identify and measure proteins by serological methods, and they probably account for the earlier claims that serum albumin in nephrosis differs from the normal serum albumin. I think the possibility of their presence in antisera is an objection to Boyden's method in which equal weights are given to antibody and antigen excess zones; the results may be unduly weighted by minor constituents. The conclusions may not be seriously affected when whole sera, which may contain the same constituents in roughly the same proportions, are compared; but when single proteins (such as hen and duck ovalbumin) which may contain variable amounts of impurity (for example, conalbumin) are compared, the results may be seriously affected; it becomes essential to avoid the antigen excess zone.

J. R. MARRACK

# HEREDITY, DEVELOPMENT AND EVOLUTION IN *PARAMECIUM**

By Prof. T. M. SONNEBORN

Indiana University, Bloomington

THE ciliated Protozoa include within a single protoplasmic mass or cell both the germ plasm (micronucleus) and soma (macronucleus and cytoplasm). The uniqueness of this and other features of their organization (see below) lends special comparative interest to their general biology. Using current knowledge of the most fully investigated ciliate, *Paramecium*, an attempt to give a synoptic view of this thesis will now be made. For details of the biology and genetics of *Paramecium*, the reader is referred to Kalmus[1], Sonneborn[2], Wichterman[3] and Beale[4].

## Heredity

The prevailing genetic system in *Paramecium* is the classical Mendelian system. In *P. aurelia*, more than twenty single gene traits have been demonstrated, including several examples of multiple alleles; but no case of linkage is yet known. These conventional genetic results are solidly founded on an essentially conventional pattern of nuclear and chromosome behaviour at meiosis and fertilization. Though *Paramecium* is normally diploid, haploids are readily obtained, polyploids have been reported, and crosses of haploids by diploids yield abnormals which are probably aneuploids. As in other organisms, the commonly used mutagenic agents are effective in inducing mutations. The chromosome theory has thus been extended to almost the farthest, and surely the most unique, reaches of the animal kingdom. *Paramecium* has proved itself entitled to a place in good standing in the world of genetics.

Another kind of heredity, clearly of subordinate rank in *Paramecium*, has been widely debated. All examples of it involve a single kind of particle, called kappa, found in the cytoplasm of some strains. Kappa determines a limited class of traits: production of, and resistance to, certain poisons, and associated physiological peculiarities. Although at first hailed as the best, almost the only, example of cytoplasmic inheritance in animals, kappa is now looked upon by most geneticists as a foreign organism. The change of interpretation was due mainly to three discoveries: though in the cytoplasm, kappa contains deoxyribonucleic acid; it is not precisely distributed to daughter cells, may be lost, and is not essential for life; and it is transmissible by infection as well as by heredity. However, it has been pointed out[5] that each of these features of kappa is occasionally exemplified by well-recognized genetic materials; and careful studies[6] of kappa not only fail to identify it with any known type of organism, but also reveal marked differences from all those types (algæ, viruses, bacteria and Rickettsiae) with which various authors had speculatively claimed to identify it. The facts prove neither that kappa is, nor that it is not, a parasite. In Lederberg's[7] useful terminology, it is a plasmid. Its chief present interest is as a model case on the important borderland between genetics and parasitology. In this connexion, the following are some of the main discoveries.

(1) When a semi-independent reproducing unit is contained within a cell, as in the case of kappa within a cell of *Paramecium*, and the two multiply at different rates, the problem arises as to how the inner one varies in quantity as the containing cell reproduces. The quantitative formulation of the solution by Preer[8] for the kappa case is generally applicable to cases of this sort. (2) When two types of plasmids coexist in the same cell, how—if at all—do they affect each other? Dippell[9] and Hanson[10] have examined this problem in the case of pairs of types of kappa. They find that the results depend upon the particular types of kappa and on the conditions. Two types may be maintained in equilibrium or the equilibrium may shift in either direction, in the extreme case one type being lost entirely. Certain combinations of types exhibit symbiotic relations, one permitting the other to reach intracellular population-levels it could not attain alone. Such studies could lead to control of populations of plasmids, with obvious implications for therapy of intracellular parasites. (3) Reciprocal interactions occur between kappa and the nuclei of *Paramecium*. The amount of kappa in the cell is proportional to the dosage of one gene (*K*), permitting the exploitation of kappa as a measure of gene action[11]. Another genotype (*kk*) normally results in rapid loss of kappa; but when exposed to certain conditions at a critical time, it maintains kappa[12]. The possibility that, in this case, kappa may be acting as an agent of intracellular transduction of genes from one nucleus (*K*) to another (*k*) is under investigation. Finally, a special kind of killer contains a kappa (called *mu*) that determines injury to, and even destruction of, micronuclei[13]. The nature of this genetic damage remains as yet unknown.

## Development

Differentiation in *Paramecium* is largely intracellular, most of it being completed before the first post-zygotic fission. Differentiation, development, growth and maintenance of all functions are dominated by the action of the macronucleus. The micronucleus may be lost without vegetative damage; but loss of the macronucleus is quickly followed by degeneration and death[14]. Immediately meiosis and union in conjugation become impossible. Feeding and growth soon cease; no divisions occur; death comes within about two days. When both types of nuclei are present and contain different genes, no effects of those in the micronucleus can be detected[15].

Two of the important early differentiations are nuclear. The first is a differentiation of the first four products of the fertilization nucleus into two micronuclei (diploid) and two macronuclei (highly polyploid). This differentiation is correlated with brief localization of the nuclei at opposite ends of the body: the two at the posterior end become macronuclei (Chao, unpublished). Immediately the two types of nuclei migrate to the same body region and thereafter lie side-by-side and reproduce true to type at all subsequent fissions. This differentiation into germinal and somatic nuclei is irreversible. At about the same time, the macronucleus becomes irreversibly determined as to the mating type it will control. The nature of this second nuclear differentiation is unknown. Both nuclear differentiations can be effected by the

* Substance of three lectures delivered at University College, London, during March 9–11.

cytoplasm, which is itself under control of the pre-fertilization macronucleus[16].

Two later differentiations also involve the macronuclei. The first is reversible and can occur at any time. This is the type of antigen carried on the many cilia[4]. Any one of several may be present: but as a rule all cilia of one cell and of its descendant cells carry the same antigen. Changes of serotype can be induced by a number of conditions, the new type of antigen persisting long or permanently during reproduction under standard conditions. The array of potential serotypes is determined by a corresponding array of non-allelic genes in the macronucleus. The environment and cytoplasm determine which of these genes comes to persistent expression.

The second later differentiation is progressive and continuous. It is characterized by decreasing fission-rate and increasing frequency of abnormality and death until all progeny are dead after at most somewhat more than three hundred successive fissions. These age changes seem to be due to progressive chromosomal unbalance resulting from the amitotic division of the macronucleus, as suggested by Fauré-Fremiet[17]. The germ plasm (micronucleus), lying directly in the increasingly abnormal cytoplasm, shows also progressive deterioration: the chromosomes become chromatin-poor, clump on the spindle, and are unequally distributed at mitosis and meiosis. This leads to increasing frequencies of abnormal and non-viable offspring at autogamy, as the parent clone ages, and ends with 100 per cent death at autogamy in parents about two hundred fissions old or older. Micronuclear damage is not accumulated at a uniform rate, but is specifically a feature of senescence. By means of conjugation, a normal micronucleus from a young cell may be substituted for the genetically damaged nucleus of an old cell. This results in complete rejuvenescence. The disastrous individual and genetic consequences of senescence are largely, if not exclusively, a laboratory phenomenon due to continuous overfeeding under uniform conditions. Either autogamy or conjugation is probably induced early in Nature, for starvation is their natural stimulus.

The gullet regularly disappears when the defective micronuclei in old cells come into action, through their derived macronuclei, after autogamy in very old clones. Substitution of a normal nucleus (see above) prevents this (Dippell, unpublished). Hence, the maintenance of the gullet depends on the macronucleus. This is of special interest because the gullet is a visibly self-multiplying structure at fission. As with kappa, a proper nuclear constitution is needed for maintenance of a self-reproducing cytoplasmic structure. Conversely (see above) nuclei are injured and lost in defective cytoplasm.

## Evolution

Though world-wide in distribution, populations of *Paramecia* are isolated in a pond, lake or stream and their means of migration are not clearly known. Theoretically, single populations of any size could be homozygous and uniform; but diverse types are known to occur together[18]. Also the same genotype, even a rare one, may be found year after year in the same place. Taxonomists recognize eight to sixteen species, differing in morphology[3]. Each of these that has been studied extensively consists of a number (6–16) of genetic species[3].

The genetic species of one taxonomic species exhibit geographical, sexual and genetic isolating mechanisms. For example, some species of *P. aurelia* are rather narrowly localized, while others are widely distributed[19] and most combinations of species cannot mate with each other; only a few interspecific crosses can be made. In one combination of species, the basis of the genetic bar to gene flow lies in a mutual incompatibility between the nucleus of each species and the cytoplasm of the other, yielding non-viable $F_1$ [18]. Similar non-viability of the $F_1$ appearing earlier, during the cross, is known for one combination of species of *P. bursaria*[20]. In most species crosses in *P. aurelia* the $F_1$ survives, but the $F_2$ and back-cross generations fail to yield viable recombinants[21].

Similar, but less extensive, non-viability of recombinants appears after crosses of any two strains from different natural populations[22]. From 15 per cent to more than 90 per cent of the autogamous $F_2$ may die in crosses of different strains. This probably has its basis in the distinctive chromosome sets of each natural strain. The strains of the one species of *P. aurelia* thus far examined form an aneuploid series (with $n = c.\ 35 - c.\ 50$) and the chromosome sets differ also in size and shape[22]. The preservation of suitable new genotypes is facilitated by the occurrence of autogamy and mechanisms for permitting conjugation between animals of identical genotypes. There is thus in Nature a continuous gradation from complete viability following clonal crosses within a strain up to 100 per cent non-viability in the $F_1$ of certain species crosses and finally to complete sexual isolation.

The breeding systems have evolved to serve two functions: the prevention or cure of senescence by periodically producing new balanced macronuclei, and the production of genetic recombinations. The mechanisms for bringing about outbreeding are most efficient in *P. bursaria*. Inbreeding leads to high mortality[23], autogamy does not occur, selfing is rare, diverse mating types rarely arise from the progeny of a single pair of conjugants, and the existence of systems of multiple mating types favours the occurrence of conjugation. On the contrary, other species with low mortality after inbreeding may have autogamy, frequent selfing, frequent occurrence of diverse mating types among the progeny of a single conjugant pair, and systems of only two mating types. The latter arrangements favour the frequent occurrence of fertilization under conditions in which recombination is excluded, thus indicating the existence of another function. In agreement, ageing is more rapid in such species[24] than in *P. bursaria*[25].

The genetic system in *Paramecium* shows striking integration of nucleus and cytoplasm into a highly evolved complex[16,26]. The mechanism of determining macronuclei, the mechanism of mating-type determination and ageing with its genetic consequences (see above), all involve systems in which the nuclei are determined by the cytoplasm and the cytoplasm by the nucleus to yield cyclic nucleo-cytoplasmic interdeterminations. Even if the genes were the exclusive original genetic materials which created the cytoplasm, there are here three important examples of how the created has become able, Pygmalion-like, reciprocally to control its creator.

The evolution of the morphological features of *Paramecium* illustrates what may be one of the most fundamental features of evolution. The Ciliates are believed to have evolved from the Flagellates. From the simplest to the most evolved Flagellates, the most outstanding feature of morphological evolution

has been increase in the number of fibre-forming granules and in the kinds and complexities of the fibrous structures they produce[27]. The most primitive forms have a single granule and a single fibrous structure, the flagellum. The most evolved forms have large numbers of granules forming not only flagella but also axostyles, costa, cresta, parabasal bodies, etc., of varying complexity. Replication of the basic structure, the unit granule, was followed by differentiation among its products. In the Ciliates, these granules (kinetosomes) and their fibrous products lie in rows below the body surface[28]. *Paramecium* possesses more than 3,000 such units of cortical structure. Each unit is walled off by ridges, but is open internally. Had the boundaries been completed and each unit supplied with a nucleus, *Paramecium* would be a metazoan. Instead, the single central nucleus became highly polyploid, the unit boundaries in the cytoplasm remained open, and replication failed to achieve metazoan multicellularity.

The principle of replication followed by differentiation is not limited to this protozoan line of evolution. On one hand, it can be discerned on the smaller levels of organization. The preservation of new gene functions arising by mutation is facilitated by duplication of chromosome segments. The enormous variation in deoxyribonucleic acid seems to be based on replications of sequences of a few purines and pyrimidines with variations in the sequence. The variation in the backbones of proteins involves comparable replications and variations in the sequence of about two dozen amino-acid units. On the other hand, a similar principle appears also on larger levels of organization. The lowest multicellular organisms simply repeat a basic cellular unit; evolution of higher forms involves variation in these replicated units. Proceeding further, groups of cells form a unit which is repeated and varied, appearing as metamerism. Similar relations appear on up to insect and human societies where individuals and groups of individuals form the units that replicate and vary. From the molecular to the social levels, the same fundamental tactic of evolution is seen: repeat, then vary.


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# THE NATIONAL PHYSICAL LABORATORY

## OPEN DAY

THE annual open day of the National Physical Laboratory took place on May 20. More than two hundred exhibits, nearly half of them new, were on view to two thousand two hundred guests of the Laboratory, representing industry, the universities and government departments, this record attendance being nearly twice that of last year. The General Board of the Laboratory held its annual meeting during the afternoon.

An item of topical interest was the commencement of a new research programme on helicopters. A tandem-rotor model 6 ft. long (Fig. 1) is at present being studied by the Aerodynamics Division in a wind tunnel. The forward rotor of the helicopter is fixed in position while the aft rotor can be moved longitudinally or vertically and its axis tilted fore and aft. The rotors are coupled together mechanically and driven by two 3-h.p. electric motors, housed within the helicopter body, at a maximum speed of 1,800 r.p.m. producing a peripheral tip speed of 400 ft./s. corresponding to a radial acceleration of 2,340 *g*. To keep the masses of the blades as low as possible, they are made of hollow magnesium alloy with leading edges of brass, so that the centre of gravity of each blade is approximately coincident with its centre of pressure, thus reducing distortion in twist. To safeguard personnel in case of blade failure, the tunnel has been reinforced with steel plate.

Many of the difficulties encountered in high-speed flight with fixed-wing aircraft are due to flow-separation from the surface of a wing either near the leading edge or at a shock wave lying farther aft. The Division is studying this phenomenon and demonstrated the detailed observation of the flow around two-dimensional aerofoils at transonic speeds. The new 36 in. × 14 in. induced flow tunnel which operates up to a Mach number of 1·8 was shown. At present still being calibrated, this tunnel will be used for studying flow past aerofoils and the aerodynamic damping of oscillating wings. As the flow-separation parameters of aerofoils cannot, in general, be varied independently over a wide range, experiments are in progress on flow-separation induced by shock waves from flat and curved plates. This enables the conditions leading to flow-separation from unswept wings to be predicted and its effects understood. Swept-back wings present special problems, and detailed observations of flow are being made at high subsonic, transonic and supersonic speeds. Among the boundary-layer control techniques being investigated is the use of suction through a porous skin; an example of this on display in a low-speed tunnel was a body of revolution representing a fuselage with a central section perforated to apply the suction.

The Control Mechanisms and Electronics Division displayed a magnetic storage drum, identical to that now fitted to the ACE pilot model digital computor, which embodies an improved shift system to move sixteen pairs of heads into eight positions, so providing 128 tracks each 1,024 digits long. The drum is constructed of bronze coated with a tough 0·001-in. thick layer of magnetic oxide in epoxy resin. The high density of this coating results in excellent magnetic properties, so that one digit occupies only 0·012 in. square. Another device, which has been

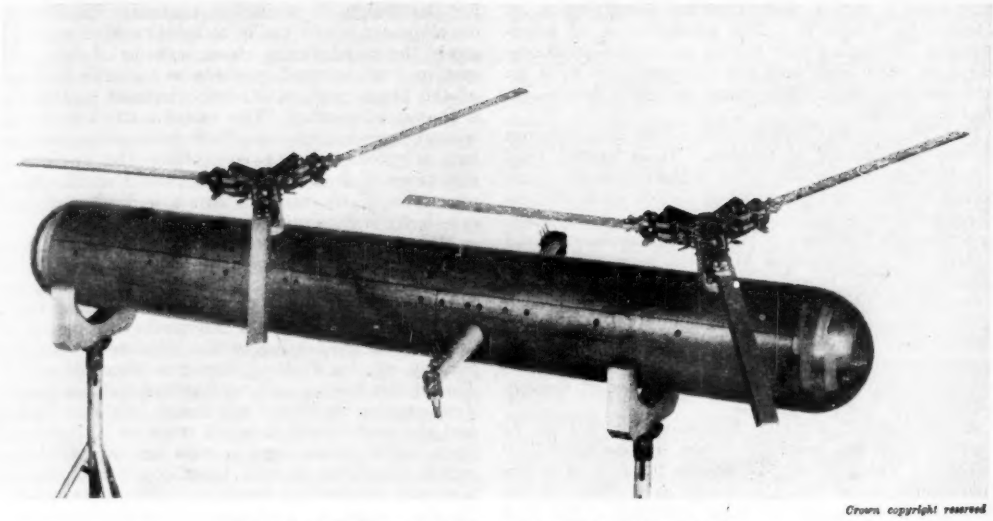

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Fig. 1. Tandem-rotor model helicopter being used for wind tunnel tests

developed for the British Coal Utilization Research Association, is a data processer fitted to a commercial self-balancing recorder so that the voltage at each of sixteen inputs is recorded sequentially by means of an automatic typewriter or a card puncher. The device contains a photo-etched brass disk, the etched portions of which are filled with insulating resin in contact with brushes which energize relays in a pattern dictated by the angular position of the disk.

The N.P.L. electronic simulator has been enlarged and is now available for use by industry. Its scope has been extended by the addition of a number of non-linear units including a general function generator.

Apparatus for the detection of atomic resonance in a cæsium atomic beam was demonstrated by the Electricity Division. Based on the work of Rabi, a resonance at 9192·632 Mc./s. resulting from the interaction between nuclear and electronic spin is found by injecting a radio-frequency signal into a stream of cæsium atoms focused sharply on to a slit by two magnets. Behind the slit the beam is detected by a hot tungsten wire which boils off the cæsium as ions, producing a current which can be measured. At resonance the beam is de-focused, resulting in a fall of this ionic current. By using an exciting field normal to the beam, Doppler effect is eliminated; a high vacuum prevents broadening by collision while saturation is obviated by using each atom once only. Thus, as the $Q$ of the system is $3 \times 10^7$, the frequency of resonance should be determinable to better than one part in $10^9$ and will be used for calibrating quartz standards of frequency and time.

The Light Division displayed a three-tier double trichromator consisting of three dispersive systems each similar to a van Cittert double monochromator with cancelling dispersions in the two stages. The systems are mounted vertically above each other, and a series of wedges enables the various intensities to be controlled. The trichromator is being used for a new determination of the colour-matching properties of the average eye with special attention to the differences between observations for small and large colour patches.

The Division is collaborating with the Metrology Division in experiments to determine the density of mercury to one part in $10^6$, an accuracy necessary to exploit fully the new primary standard barometer. Two hollow cubes with 75 mm. sides have been built up from fused quartz plates wrung together. The precision of manufacture of these plates is such that, before wringing, each face was flat to 0·1 fringe, and the angles within 0·2″ of 90°. The volumes of the cubes will be known to one part in $10^6$. They will be filled *in vacuo* through a small capillary in the top plate and the mercury contents weighed to determine the density. This experiment supplements another determination based on the weighing in mercury of an equally precise solid cube of tungsten carbide of 3·5 in. face.

The Mathematics Division displayed DEUCE (digital electronic universal computing engine), an improved and engineered version of the ACE pilot model. This machine is the first of several being built by the English Electric Co. It uses the binary scale to represent numbers by trains of pulses generated at 1 Mc./s. Numerical data and instructions are injected from punched cards and the results recorded similarly, either in binary form for later computation or in decimal form for printing. It has high-speed mercury delay-line storage as well as a magnetic drum similar to that described above. The Division also demonstrated new punched-card equipment, including an electronic calculating punch which can multiply two 20-digit numbers together in a second.

The Metallurgy Division is investigating grain-boundary embrittlement. While studying the properties of pure iron, it was found that slight additions of certain impurities sometimes caused extreme embrittlement. Unlike the well-known effect observed in gold containing bismuth, there is no precipitation of a separate identifiable phase in the boundaries, and the magnitude of the effect depends on the heat treatment of the alloy. In the absence of any discrete phase, there is no complete explanation of the extreme embrittlement, but it

seems likely that some segregation of foreign atoms must occur; various techniques are being used in an attempt to detect it. The phenomenon of intergranular brittleness also occurs in copper–antimony alloys at both high and low temperatures with an intermediate temperature-range in which brittleness does not occur.

The Division has commenced a new investigation on the mechanism of fatigue. It is known that certain changes may take place in the lattice structure during fatigue, and attempts to detect such changes at an early stage in the process are now being made by focusing a fine beam of partially monochromatized X-rays on a small area in which repeated slip is occurring. Thin specimens are used permitting the photographic observation of the low-angle scattering of the transmitted beam. Initial observations on copper have shown a very characteristic low-angle pattern produced in conditions of fatigue, and this can be interpreted in terms of changes of density occurring in the slip plane.

A mechanical fiducial indicator for fitting to proving rings has been developed by the Metrology Division. This not only facilitates the setting of the micrometer screw but also shows at a glance if the deflexion is changing and thus indicates if the load is subject to vibration or creep. Although the wavelength of light is now used for many precise length determinations, line standards and scales are still of fundamental importance, and an investigation is proceeding on their intercomparison by photographic means. A graduation line is a shallow groove, and the density of its photographic image falls off gradually as one moves across it. However, the maximum change of density is well defined and is independent of both the characteristics of the emulsion and its processing. By observing the density gradient with a microphotometer, it is hoped to compare two standards to an accuracy of a few hundred thousandths of a millimetre.

One item of considerable contemporary importance was a comparator for measuring the pitch errors of the fir-tree-root serrations of gas turbine blades. The blades are mounted in such a way that measurement of the vertical heights above a datum formed by the lowest serrations gives the spacings rapidly and with high accuracy.

To meet the requirements of organizations doing research at low temperatures, the Physics Division is arranging to make liquid helium for them in its Collins cryostat. Up to 15 litres will be supplied in double 'dewars' cooled with liquid nitrogen, and the helium gas evolved in use collected for re-liquefaction. The Division has just completed the most comprehensive series of experiments yet conducted for the determination of equal-loudness contours for the human ear. This work was carried out at the request of the British Standards Institution, and the results should form an acceptable basis for a new standard in subjective acoustics.

Recent increased demand for heat insulation at low temperatures has resulted in the development of appropriate apparatus to measure the thermal conductivities of various materials. The heat flow is from a source at room temperature to a sink cooled by liquid nitrogen or solid carbon dioxide. Samples of materials such as fine fibred glass, expanded plastic and lightweight powder have already been tested.

The Ship Division demonstrated a new apparatus which determines the rate of saturation of air from bubbles in water, information on this being required for the design of cavitation tunnels. Another new development is the use of radio-controlled models to study the manœuvring characteristics of ships. The system demonstrated operates on a carrier frequency of 465 Mc./s. with nine audio channels each feeding a change-over relay. The relays control three star-wound repeater motors which drive the rudder and two selector switches controlling the speeds and directions of the two propulsion motors. The rate of operation of the shore controls is limited to scale speeds by centrifugal governors.

Midwives may now administer trichloroethylene B.P. as an analgesic with inhalers approved by the Central Midwives' Board, which issues a certificate of approval of satisfactory apparatus valid for six months. The National Physical Laboratory has undertaken the testing of the inhalers to the specification of the Medical Research Council, and the Test House has set up a new section for this purpose. Temperature-controlled boxes each hold four inhalers, and the trichloroethylene–air mixture is drawn from them by a special pump with an adjustable rate which simulates human breathing. For the high accuracy required, a Rayleigh refractometer is used for the volumetric analysis; other tests include the measurement of resistance to airflow and mechanical inspection.

A. J. Garratt

## BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

### OPEN DAYS

The British Non-Ferrous Metals Research Association is this year celebrating the twenty-fifth anniversary of the opening of its own laboratory premises at Euston Street in London. The occasion was marked by a visit from H.R.H. the Duke of Edinburgh on May 23, and for the remainder of the week the laboratories were open to the representatives of member firms, government departments and others.

The original laboratory block in Euston Street was almost completely destroyed by enemy action during the Second World War; but it has since been rebuilt and now houses most of the Association's general metallurgy work and its metal-working plant. The laboratories have, however, been expanded considerably into adjacent blocks of buildings and now cover a floor area of about 43,000 sq. ft. and house a staff of about a hundred and fifty. The exhibition of work in connexion with these open days covered a very wide range of subjects, and in this short note it is only possible to refer to a few of those having a more purely scientific appeal.

For some years now the Association has been investigating the causes of the pitting corrosion of copper water-pipes which occurs in certain localities in Great Britain. Pitting corrosion is comparatively rare and usually affects only a few installations in any particular area. It has been found to be associated with cathodic films occurring under certain circumstances in the bore of copper pipes. The fact that pitting corrosion is rare is probably due to the presence of a natural inhibitor in many supply waters, and a great deal of work has gone into the separation of this inhibitor and in attempts to identify it.

The method of isolating the inhibitor consists in evaporating water under reduced pressure to produce a concentrate of the inhibitor. The inhibitor is precipitated from this as a copper salt, and a hydrochloric acid solution of this precipitate is extracted with ether. Distillation of the solvent leaves a crude concentrate of inhibitor which is then subjected to vacuum sublimation. Paper chromatography has been used for attempting to identify the constituents in this crude inhibitor and to compare these constituents with known substances. The stage has now been reached when substances reacting in the same manner as the extract of natural inhibitor have been shown to inhibit pitting corrosion of copper when added to water in quantities as small as the amount of natural inhibitor present in many water supplies.

Another interesting exhibit concerned the use of ion-exchange resins for analytical work. These are now being used extensively in the Association's laboratories for facilitating the analysis of electroplating solutions and for general metallurgical analysis. One example is the accurate determination of the amount of trivalent chromium in chromium-plating solutions. The method in common use involves titration of the hexavalent chromium of one sample and, after oxidation of another sample, titration of the total chromium. The trivalent chromium content is given by the difference between the two titrations, and this may sometimes be as little as 0·2 ml., so that small errors in measurement can easily give a misleading result. Using an ion-exchange column, the small amount of trivalent chromium present can be separated from the hexavalent chromium and titrated with ferrous ammonium sulphate of appropriate strength. The solution is passed through a column which retains the trivalent chromium. After washing the column with water to remove all the hexavalent chromium, the column is eluted with dilute sulphuric acid and the solution of trivalent chromium so obtained oxidized and titrated.

It is of interest to note that the laboratories have also recently built a demineralizing plant for the production of water for use in analytical work. The plant consists of an ion-exchange column with a mixed bed of anion- and cation-exchange resins. It will produce about 80 gallons of water between regenerations at the rate of about 10 gallons/hr. The water is purer than that obtained from ordinary laboratory stills, and running expenses are considerably below those of electric stills.

The mechanical testing section of the laboratories has recently developed a short-term fatigue test enabling a rapid assessment to be made of the endurance limit of many materials. The test is based on the Wöhler type of fatigue machine ; but the load is applied by means of a spring. The load is gradually increased during the course of the test by extending the spring, using a slow-motion drive from the main drive of the fatigue machine, and the specimen is broken in a period which may range from four or five hours up to about a day. The extension of the spring at the moment of failure gives the 'dynamic breaking stress' for the specimen, and it has been found that, for lead alloys, copper alloys and steels, there is a direct correlation between this stress and the endurance limit of the material. The test is likely to expedite considerably the exploration of the fatigue properties of new materials.

The development of a non-destructive method for measuring the thickness of electroplated coatings has long been needed by the plating industry. This problem has recently been solved in the Association's physics laboratory using a method based on a thermoelectric effect. A heated probe is applied to the surface of the electroplated specimen, and a cold probe is placed on the coating at some short distance away. The interface between the coating and the basis metal under each probe can be considered analogous to the hot and cold junctions of a thermocouple, and the e.m.f. generated is amplified and measured on a galvanometer. The reading obtained is proportional to the thickness of coating for any given coating–basis metal combination and, if necessary, the instrument can be calibrated to read directly in terms of coating thickness. Already several firms have made extensive field trials with the equipment, and arrangements have been made for two firms of instrument manufacturers to produce it commercially.

In the physics laboratory there has also been shown a method for vacuum-etching metallographic specimens, which is used where ordinary chemical or electrolytic etches have proved unsatisfactory. In this method the specimen is made the negative electrode and is etched at 1,000–4,000 V. in argon at a pressure of 1–100 $\mu$ of mercury. The etching time has been found to vary from fifteen minutes to several hours according to the nature of the specimen. It appears to yield particularly good results on some aluminium alloys, such as the aluminium–1½ per cent manganese alloy, and has also been used for revealing grain boundaries in copper which could not be seen by ordinary etching techniques.

One exhibit in the general metallurgy section of particular interest to the fundamental scientist concerns work which the Association is carrying out on the properties of grain boundaries. For this work bi-crystals of copper, the orientations of which with respect to each other are known, are being subjected to shearing forces tending to move one crystal relative to the other. The magnitude of these forces is such that at the test temperature plastic deformation of the crystals themselves is negligible. Optical interference methods are being used for tracing the relative movements of the crystals, and by this technique movements as small as 500 A. can be observed. Eventually it is hoped that this work will give an indication of the part which grain-boundary movement plays in the behaviour of metals in slow creep.

## THE WATER POLLUTION RESEARCH LABORATORY, STEVENAGE

THE Water Pollution Research Laboratory—one of the fourteen research stations of the Department of Scientific and Industrial Research—was set up in 1927. Until recently it had no permanent buildings of its own, and its work was carried out in a number of temporary laboratories in different parts of Britain. The official opening on June 20 of a permanent central laboratory at Stevenage therefore marks an important stage in the history of the organization.

In 1927 there were many urgent and serious problems of pollution of surface waters, particularly by industrial effluents, and indeed the organization was formed as the result of representations made at that time to the Lord President of the Council by a

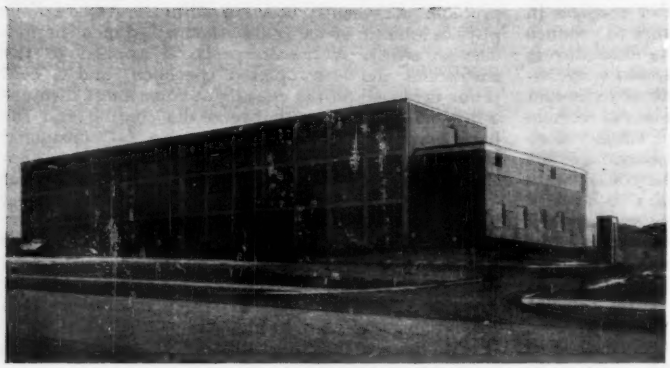

Fig. 1. Water Pollution Research Laboratory, Stevenage

deputation representing water supply undertakings, medical officers of health, and fishery authorities. At first, therefore, the work of the organization was mainly on the development of methods of purifying particular industrial wastes; several years, for example, were spent in working on waste waters from the beet-sugar industry and from the milk industry, both of which were causing serious pollution in rural districts. In 1927 very little was known in detail of the effects of different types of polluting substances on fish, though it was clear that fisheries in many parts of Britain were rapidly being destroyed. Accordingly, during 1929–33 a survey of the estuary of the River Tees was undertaken; this was chosen as typical of several estuaries which had become impassable to migratory fish, and in which the numbers of salmon caught by anglers in the upper river and by net fishermen in the estuary itself were declining rapidly. As a result of this work, a better understanding was obtained of the effects on a fishery of directly toxic substances and of depletion of dissolved oxygen brought about by the oxidation by bacterial action of organic substances discharged as constituents of industrial wastes and sewage effluents. At that time, also, some local authorities were finding difficulty in purifying domestic sewage, as a result of the discharge to the sewers of industrial liquors containing substances which inhibited the microbiological processes on which the treatment of sewage very largely depends. The discharge of industrial wastes to domestic sewers —which is admitted to be on the whole a good policy—has increased considerably since the formation of the Laboratory, and a great deal of work has been done to determine the effects of important constituents on sewage treatment, and the maximum concentrations which can be tolerated. It is now becoming common practice in industry to remove particularly noxious constituents so that the remaining effluent can be treated in admixture with sewage without interfering unduly with the purification of the mixture at a sewage-disposal works. There are, for example, plants in many parts of Britain for removing chromate, cyanide and toxic metals from effluents from the metal industries before these are discharged to sewers.

Since 1927 the view taken of pollution by industry has changed considerably, and it is now generally realized that it is essential in an industrial and thickly populated country such as Great Britain that rivers should be maintained in a reasonable state of purity. There has been a substantial increase in the volume of water distributed for domestic supply, and of this a large proportion is drawn from surface sources. Many of these sources have already received industrial and sewage effluents, and the cycle of discharge and re-use can only be operated if these liquids are effectively treated before discharge, so as to permit further natural purification to take place in the river, giving a water suitable for subsequent treatment at a water works. Industry is in much the same position, since the water supply of one factory commonly contains effluent from another factory—and often from a great many factories—discharged farther upstream. Since 1927, therefore, many industries, realizing the importance of effluent treatment, have themselves undertaken research, either at individual factories or through research associations. Examples of the kind of work done and of the success which has in many cases been achieved were given in a recent symposium organized by the Society of Chemical Industry (see *Nature*, **175**, 790; 1955). It is an excellent thing that research on the treatment of an industrial effluent should be undertaken within the industry itself, since often the best and most economical solution is found, not by devising a method of treatment for a liquid already being discharged, but by modifying the processes of manufacture so as to reduce both the volume of the effluent and the quantity of material which it carries away with it to waste.

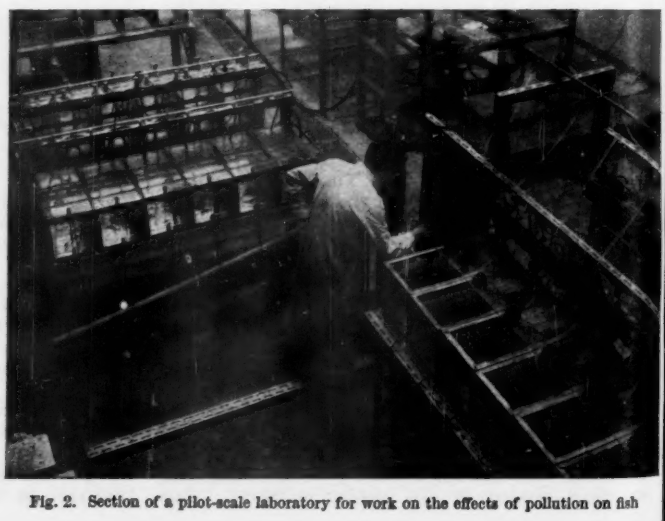

Fig. 2. Section of a pilot-scale laboratory for work on the effects of pollution on fish

The Water Pollution Research Laboratory is in close touch with much of the work of this kind which is carried out in Great Britain; but now that industry is taking an increasing part in the solution of its own problems, it is becoming possible to devote a bigger part of the resources of the organization to work of a more general and basic kind. The need for such work has become more important with the formation in 1948 of river boards with powers to lay down standards of quality of effluents which may be discharged into particular rivers. It is clear that before this can be done effectively, a river board must be able to predict, within reasonable limits, what will be the effect of discharging a given effluent on the general properties of a river—on its suitability, for example, for a domestic or industrial water supply or on its ability to support a fishery. To give an accurate answer to such a question requires much more information than is at present available on rates of oxidation of different substances in rivers, on the rate of absorption of oxygen by water from the air, on the effect of plants on the oxygen balance, on the long-continued effect of toxic substances on fish, and so on. This kind of long-range investigation is at present occupying a large proportion of the effort of the Laboratory. For example, a detailed study is being made of the conditions in the very polluted estuary of the Thames, some fifteen miles of which now contain no detectable oxygen in solution in dry weather. Here information is required on what the effect on this condition would be of changing various factors—for example, the input of oxidizable matter in sewage and industrial effluents, the temperature (which is appreciably raised by the discharge of cooling-water from power stations), and the freshwater flow. Having studied, so far as possible, the components of the problem in the laboratory, the distribution of dissolved oxygen under present conditions has then to be predicted, taking into account the complex system of mixing and flow of fresh and salt water in an estuary. The validity of the data used in the calculations can be checked by comparing the predicted distribution of dissolved oxygen with the observed distribution; when it has been shown that the data used are reliable, it is then not unduly difficult to predict what changes will follow from altering any of the factors which affect the oxygenation of the water. On such information, it is hoped, future policy concerning the estuary will be based.

In collaboration with the Ministry of Agriculture, Fisheries and Food and the Freshwater Biological Association, a study has been begun of the effects of pollution on freshwater streams. Much of the information gained in the survey of the Thames Estuary—particularly on the factors which affect the oxygen balance—will be immediately applicable in this new work.

The present staff of the Laboratory includes chemists, physicists and biologists; usually these work in combined teams—an arrangement which is often of great mutual benefit. The new Laboratory was designed for a research staff (scientific officers and assistants) of about eighty-five; the present number is fifty-three. It has a floor space of about 40,000 sq. ft. and includes under one roof a three-storied block of which the top floor includes the library and office accommodation and the other two floors small-scale laboratories, and a single-storied wing containing four pilot-scale and associated analytical laboratories. One section of this wing is designed as a low-activity radiochemical laboratory. In this, work is being carried out on the removal of radioactive substances from water; this section also undertakes for the rest of the Laboratory work involving the use of radioactive tracers. Two of the pilot-scale laboratories are specially designed for work with fish, and these are provided with a separate unchlorinated water supply from a bore-hole. A feature of the Station is that up to 70,000 gallons of domestic sewage can be pumped daily from a sewer crossing the site for use in large-scale experimental work in plant built in the open. The services are in general simple and orthodox; but where advantageous, use has been made of modern techniques and materials. Each laboratory contains an electrical circuit, operated from a master clock, from which impulses can be taken at intervals of 1 or 30 seconds; these operate relays and are widely used for marking time-scales and for controlling automatic apparatus. Another feature which has proved generally acceptable is that on suitable walls of each laboratory there are permanent metallic studs to which 'Dexion' or similar frame-work can be attached without boring holes in the wall. Distilled water is prepared centrally, using an automatic gas-fired boiler and a set of strip-action condensers in 'Pyrex' glass. Waste waters from the laboratories are drained through polythene waste pipes.

There is a transport section to assist in field-work, and metal-working and wood-working shops are provided for the construction of prototype apparatus designed and used in the laboratories.

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# OBITUARY

## Prof. E. Regener

Erich Regener, who died on February 27, was born in Schleussenau near Bromberg on November 12, 1881. He studied physics under E. Warburg in Berlin, worked from 1909 onwards with H. Rubens at the Physics Department of the University of Berlin, and became, in 1911, professor of physics and meteorology in the Landwirtschaftliche Hochschule, Berlin. In 1920 he was appointed director of the Physics Department of the Technical High-school at Stuttgart, which, under him as experimental physicist, and with P. P. Ewald as theoretical physicist, soon became a lively centre of learning and research.

Regener is perhaps best known for his work on the intensity of cosmic rays under water and in the upper atmosphere. He was a pioneer in both fields, and at one time held both the depth and height records for cosmic-ray measurements: 230 m. below the surface of Lake Constance and 25 km. up in the atmosphere. These two achievements revealed his great experimental skill and ingenuity in the design of apparatus. Regener also made many important contributions to atmospheric physics, particularly in the study of ozone and of the physics of the crystallization of water.

During the Hitler regime, Regener had to resign his post at Stuttgart as his wife was a non-Aryan. However, he found support from the more liberal Kaiser-Wilhelm-Gesellschaft, as director of a laboratory at Friedrichshafen for the investigation of the stratosphere. When, during the War, his laboratory was destroyed during an air raid, he built a small research station at Weissenau on Lake Constance, which, after the War, became part of the

Max-Planck-Gesellschaft. Both his children by his first wife (who died shortly after the War) had to emigrate as 'half-Aryan': his son Victor, also distinguished as a physicist, to the United States, and his daughter, married to the physicist Dr. Rathgeber, to Australia. After the War, Regener became a senator and vice-president of the Max-Planck-Gesellschaft.

Regener possessed exceptional personal charm and a wide liberal culture. He was both a good violinist and a keen yachtsman. His death means the loss to German science of a creative experimental physicist and one who, having weathered the devastation of the Hitler regime and of the War, afterwards did much to help to rebuild its great tradition.

P. M. S. Blackett

# NEWS and VIEWS

## Entomology at Rothamsted: Dr. C. B. Williams, F.R.S.

Dr. C. B. Williams, who has been head of the Department of Entomology of Rothamsted Experimental Station since 1932, retires on June 30. From Birkenhead School he went to Cambridge, where he took a science degree and the diploma in agriculture, and then to the John Innes Horticultural Institution, where he was one of Bateson's first research students. Between 1916 and 1927 he studied pests of sugar-cane in the West Indies, and then pests of cotton in Egypt, where he was sub-director and then director of the Entomological Department of the Ministry of Agriculture. In 1927 he was appointed entomologist at the Amani Research Station in East Africa, where his work on locusts enhanced his already great interest in the migration of insects—a subject that has since continued to fascinate him and in which he has become one of the leading authorities. During 1929–32 he was Steven lecturer in agricultural and forest zoology in the University of Edinburgh, after which he was a visiting professor in the University of Minnesota before going to Rothamsted. In addition to continuing his studies on insect migration, at Rothamsted he has been concerned with problems of field ecology and the relation between weather and the activity of insects. He has been a pioneer in applying statistical methods to biology and has contributed much to knowledge on intra-generic competition and on the relative abundance of different species in wild populations of many kinds of organisms. Dr. Williams has been president of the Royal Entomological Society, the British Ecological Society and the Association of Applied Biologists. Aided by a grant from the Agricultural Research Council, he will continue his work on quantitative ecology at Kincraig, Inverness-shire.

## Dr. Kenneth Mellanby, C.B.E.

Dr. Kenneth Mellanby, who is to succeed Dr. C. B. Williams, has until recently been principal of the University College, Ibadan. After taking the Natural Sciences Tripos at Cambridge, he did his first research at the London School of Hygiene and Tropical Medicine, starting to study insects and climate, a subject that has remained his main interest. In 1934 he was awarded the Wandsworth Fellowship and for two years worked on the tsetse fly in East Africa. Then, as the Sorby Research Fellow of the Royal Society, he went to the University of Sheffield, where he was appointed honorary lecturer in zoology. Here, in addition to studying the effects of environment on the behaviour of various insects, early in the War he undertook work on head lice and scabies. In 1943, as a major in the R.A.M.C., he conducted a casualty survey among prisoners-of-war in North Africa, and in 1944, as deputy field director of the Medical Research Council Scrub Typhus Commission, he went to South-East Asia, where he was particularly concerned with organizing preventive measures against the disease. On his return to the United Kingdom, he was appointed reader at the London School of Hygiene and Tropical Medicine, a post he relinquished in 1947 to become the first principal of the new University College, Ibadan, where he also held the post of professor of parasitology. Since 1953 he has again been working at the London School of Hygiene, studying the manner in which insects can be acclimatized to withstand extremes of temperature.

## Geology in the British Museum (Natural History): Mr. W. N. Edwards

Mr. W. N. Edwards, who has been keeper of geology at the British Museum (Natural History) since 1938, is to retire on June 30. From the Cambridge County School he went to Christ's College, Cambridge, and was appointed to the Museum staff in 1913 as a palæobotanist. He has travelled widely and collected fossil plants in many parts, and his published papers cover a varied range of palæobotanical subjects. In the Department of Geology he has been particularly active in forwarding the publication not only of monographs and scientific papers but also of popular handbooks. He was a secretary during 1939–44 of the Geological Society, and recently he received the Lyell Medal of the Society. He is president this year of Section C (Geology) of the British Association.

## Dr. E. I. White

The Principal Trustees of the British Museum have appointed Dr. Errol Ivor White to succeed Mr. Edwards as keeper of the Department of Geology. Dr. White has been deputy keeper of the Department since 1938. Educated at Highgate School and King's College, London, he entered the British Museum (Natural History) in 1922, when he was given charge of the fossil fishes under the late Sir Arthur Smith Woodward. He has since specialized on the ostracoderms, and has published numerous papers on primitive vertebrates. He has collected fossils extensively in the Anglo-Welsh basin, and has also taken part in expeditions to Madagascar and Spitsbergen.

## The Smithsonian Astrophysical Observatory

It is announced that the Smithsonian Institution and Harvard University will in future co-ordinate their programmes of astrophysical research. In pursuance of this policy, the headquarters of the Smithsonian Astrophysical Observatory will move to Cambridge, Mass., though some work will continue in the laboratories and workshops in Washington.

The two high-altitude solar observatories of the Institution, in Chile and on Table Mountain, California, will be maintained in operation. Prof. F. L. Whipple, who will succeed Mr. L. B. Aldrich on his retirement as director of the Smithsonian Astrophysical Observatory, will continue to hold his present post at Harvard College Observatory; and it is contemplated that the two bodies, though retaining their separate identities for administrative purposes, will eventually be staffed jointly.

The basic work of the Smithsonian Astrophysical Observatory from 1902 (twelve years after its foundation) to the present time has been the precise measurement of the Sun's output of radiation. This so-called 'solar constant' is a basic datum not only of solar physics but also of terrestrial meteorology. The early measurements of its magnitude were admittedly imperfect—the estimation of atmospheric absorption presents a formidable difficulty—but the instruments and the methods of observing have been steadily improved. Although the evaluation of periodicities in the variable energy output of the Sun and their correlation with terrestrial weather changes have been and are still controversial matters, there can be no doubt that the data accumulated at Washington and its field-observing stations during the past half-century represent a major contribution to the Institution's avowed purpose of "increasing and diffusing knowledge among men". The association of this work with that of the Harvard College Observatory, where solar research has also frequently followed a geophysical trend, promises well for the future study of solar–terrestrial relationships.

### Mr. L. B. Aldrich

Mr. L. B. Aldrich retires from the directorship of the Smithsonian Astrophysical Observatory after forty-two years service with the Institution. Joining in 1913 as 'bolometric assistant', he worked in association with Dr. C. G. Abbot for the greater part of the latter's life study of the solar constant and of periodicities in its measured variations. He was appointed assistant director in 1930, and on Dr. Abbot's retirement from administrative work in 1944 he became acting director, being confirmed in the post of director a year later. During his long period of service, there have been issued from the Observatory not only the long reports containing the basic data from which the solar constant is derived but also a series of papers discussing the associated instruments and observational techniques, in the development of which Mr. Aldrich has often been personally concerned.

### Prof. F. L. Whipple

Prof. F. L. Whipple, who succeeds Mr. Aldrich as director on July 1, joined the staff of Harvard College Observatory in 1931, immediately after receiving the Ph.D. degree from the University of California at Los Angeles. He has done much basic work in high-speed ballistics and aerodynamics, particularly in connexion with the Harvard programmes of meteor study; in pure astronomy he has been interested chiefly in the physics of comets, of meteors and of interstellar gas. As professor, Dr. Whipple will remain a member of the council directing teaching and research in astronomy at Harvard. As director of the Smithsonian Astrophysical Observatory, he will join the Solar Associates, a group co-ordinating solar and upper-air research at Harvard and its Climax station with allied work by the U.S. Air Force at Sunspot, New Mexico, and the Central Radio Propagation Laboratory of the National Bureau of Standards at Boulder, Colorado.

## Physiological Research on Channel Swimmers

Last year, when Butlins Ltd. organized a swimming race across the English Channel, two members of the Survival at Sea Committee of the Royal Naval Personnel Research Committee made a preliminary physiological examination of the participants and recommended that a fully organized research would be very valuable. As a result, for this year's race, which will be swum during August 10–16 by eighteen competitors, the Admiralty and the Medical Research Council are co-operating in such a full-scale investigation. The objects will be to determine so far as possible the effects of prolonged energy expenditure under cold immersed conditions and to study the biochemical changes which may arise; in particular, the fat distribution of each participant will be recorded before and after the swim. Each boat accompanying a swimmer will have on board a Royal Marines signaller, who will be in constant touch by radio with a Royal Naval vessel, Seaward Defence M.L. 3515, on which will be six scientific workers, and with two medical bases to be set up at Dover and Folkestone. The moment a swimmer gives up, the signaller will notify the scientific team and a research worker will immediately go and make an examination.

## Scientific Needs of the Army

Commemoration Day was celebrated at the Royal Military College of Science, Shrivenham, on June 18, when a large company of past and present students attended with their guests and toured the laboratories. In an address given by Field Marshal Sir John Harding, Chief of the Imperial General Staff, he said that the Army needs a much higher standard of technical knowledge and that the general purpose of the College is to raise that standard and to make fashionable a technical outlook in the Army. Two other crucial needs are, first, that the Army's requirements are properly understood by research and development establishments and by producers and, secondly, that the Army knows what science has to offer. The War Office, in conjunction with the Ministry of Supply, is to set up a special selection board to deal with the planning of the careers of technical staff officers.

## Research and Development in the Coal Industry

In referring to the report of the Advisory Committee on the Organization of the National Coal Board (*Nature*, May 21, p. 867), attention was directed to the recommendation that a research and development committee should be set up. The National Coal Board has now established a Technical Research and Development Committee consisting of J. Bowman (deputy chairman of the Board), J. Latham (finance member), Dr. W. Reid (production member) and A. H. A. Wynn (scientific member). The director-general of research (Dr. Idris Jones) and other senior officials of the Board attend the Committee by invitation. The terms of reference of the Committee are as follows: "To consider and approve, in the form of programmes and budgets, the general lines of the Board's research and development in the Production and Carbonization fields, having regard to the weight of effort to be directed to the various elements in the programmes and the

degree of priority which should be given to them; to receive progress reports; and to ensure that work on all the items in the approved programmes is properly and promptly carried out; and that useful technical information that is obtained is adequately disseminated".

On the wider issues of training for management, the Board has now appointed Mr. N. G. Fisher to be principal for its proposed Staff College, and search is being made for suitable premises. In the meantime, courses for colliery managements, as well as for some of the technical staffs at the area and divisional offices, are being run at temporary accommodation. The recruitment and training of staff are being further strengthened by the creation of a Staff Department at headquarters under Sir Andrew Bryan (staff member of the Board); and four staff directors have already been appointed to divisional boards.

## Natural Gas near Crowborough, Sussex

As part of the Gas Council's five-year search for natural gas in Great Britain, a second deep well is to be sunk in the area near Crowborough, Sussex, about a mile south-east of the first well. The arrangements are in the hands of the D'Arcy Exploration Company (a member of the B.P. group), which is undertaking the work on behalf of the Gas Council. The first well in the area, which has been carried down to a depth of about 4,500 ft., has revealed small shows of gas at several levels, and the results obtained from it, and from subsequent seismic surveys in the area, indicate that a further deep test is justified.

## The Institute of Biology

The Institute of Biology, now in its sixth year of existence, has elected as president Sir James Gray, who was one of those concerned with the initial moves which led to the foundation of the Institute and a vice-president during 1950–54. New council members for 1955 have been elected as follows: Prof. G. E. Blackman, Mr. N. W. Pirie (*vice-presidents*); Dr. N. E. Hickin (*honorary treasurer*); Mr. H. J. Bunker, Dr. R. J. C. Harris, Mr. F. R. Horne, Dr. A. S. Parkes, Dr. C. L. Smith. Honorary membership has been conferred on Lord Boyd Orr and Sir John Russell in recognition of their services both to biology and to the application of biology to the betterment of mankind. The membership of the Institute is now: 1,150 full members, 60 probationer members and 290 student members. The steady growth of membership has enabled the Institute to establish regional branches and to undertake an increasing range of activities. Further information about the Institute can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

## Bibliography of Natural History

A recent issue of the *Journal of the Society for the Bibliography of Natural History* (3, No. 2, 63; 1955) includes a number of items of considerable interest to scholars, including an address on the "Bibliography and the History of Science" by V. A. Eyles, and an important classified list of books of reference and bibliographical books on zoology by F. C. Sawyer, comprising the works of some 212 authors. V. A. Eyles also contributes a note on the earliest printed version (1788) of the "Theory of the Earth" by James Hutton.

## Natal Museum (1904–54)

The March number of the *South African Journal of Science* includes an article on the golden jubilee in 1954 of the Natal Museum. The Museum was originally sponsored by the Natal Society, which was formed in Pietermaritzburg in 1851. The Society soon acquired museum objects, which were moved from site to site until the final move was made to the present premises in Theatre Lane. Eventually it became evident that the Museum had outgrown the resources of the parent body, and the Government assumed responsibility in 1904. A series of functions was arranged to commemorate this event, the most notable being a gathering on November 30, 1954, in the Museum. An illustrated brochure on the history and development of the Museum has been published.

## Oundle School Natural History Society

A fine example of voluntary effort is the report of the Oundle School Natural History Society for 1954. Apart from its varied contents, the printing, duplicating and reproduction of photographs in the report have been tackled with enthusiasm and have led to a publication which will undoubtedly give pleasure to all who study the natural history of Northamptonshire. Besides the usual notes recording observed fauna and flora, the report contains a short article on the emergence of the hornet clearwing moth, an account of butterfly-collecting in the south of France and northern Spain and of some Welsh beetles, and a description of the distribution of *Spirorbis spirillum* and *S. borealis* on the shore at Millport.

## *Discovery*

The latest issue of *Discovery* (**26**, No. 4; April 1955) contains the usual series of articles on varied aspects of science which are of topical interest and which have been written for the intelligent layman and for the man of science who wishes to keep himself informed of developments in other fields. Among them is an account by Dr. G. Curzon of mescalin and its physiological and psychological effects. The development of automatic factories is described by Dr. S. Lilley, who gives some details of the sequence of operations in the automatic production line at a Moscow piston factory. Prof. C. M. Yonge has written an illustrated article on giant clams, while R. G. Rose contributes a short description of the life of Carl Frederick Gauss. There is also an interesting article by James Paton explaining how the Observatory on Ben Nevis came into being and fell into decay.

## The Science Masters' Association

There can be few voluntary organizations which, over a period of thirty-two years, are able to show a steady rise in membership each year. Despite the Second World War, the Science Masters' Association showed a steady increase in membership from 364 in 1919 to 4,540 in 1952. In 1953 there was a slight decline in membership; but it is pleasing to note in the annual report for 1954 that membership again showed an upward trend. The contribution made by this Association to the quality of science teaching in schools by means of regular meetings, an annual conference and the publication of its excellent journal, the *School Science Review*, is immeasurable. Among special items referred to in the report are the inquiry made by the Association into the deterioration of science teaching caused by the shortage of science masters; the findings of a sub-committee on

science teaching in secondary modern schools; and reference to an investigation into the present and future supply of laboratory assistants. The Association also has a Chemistry Teaching Aids Sub-Committee which makes contacts with industrial organizations willing to produce material for use in schools.

## Manchester Literary and Philosophical Society: Officers:

THE following have been elected officers of the Manchester Literary and Philosophical Society: *President*, Dr. P. F. R. Venables; *Vice-Presidents*, Miss A. C. Alexander, Sir Geoffrey Jefferson, Prof. J. Kenner and Dr. Norman Smith; *Honorary Secretaries*, G. F. Clayton and F. Willett; *Honorary Treasurer*, H. Hayhurst; *Honorary Librarians*, Dr. W. H. Brindley and Dr. L. Cohen; *Honorary Curator*, Donald Stephenson.

## National Research Council of Canada: Awards for 1955–56

THE National Research Council of Canada has made 267 awards for 1955–56, totalling 336,300 dollars in value. They include 62 bursaries (800 dollars each), 133 studentships (1,100 dollars) and 18 fellowships (1,400 dollars), all of which are to be held in Canada. Of the awards for study abroad, thirty-three special scholarships, worth 1,900 dollars each, have been granted which will be held in the following countries: nineteen in the United Kingdom, eleven in the United States, and one each in France, Sweden and Denmark. Twenty-one overseas postdoctorate fellowships at 2,500 dollars each have been granted for work in the following countries: fifteen in the United Kingdom, two in The Netherlands, and one each in Sweden, Denmark, France and Belgium.

## The Night Sky in July

FULL moon occurs on July 5d. 05h. 28m., U.T., and new moon on July 19d. 11h. 34m. The following conjunctions with the moon take place: July 18d. 04h., Mercury 0·1° S.; July 27d. 19h., Saturn 6° N. In addition to these conjunctions with the moon, Mars is in conjunction with Jupiter on July 24d. 22h., Mars 0·6° N.; Venus with Pollux on July 27d. 08h., Venus 6·2° S.; and Mercury with Pollux on July 27d. 15h., Mercury 5·8° S., and also with Venus on July 28d. 01h., Mercury 0·3° N. Mercury rises in the early morning hours at 3h. 05m., 2h. 40m. and 3h. 45m. on July 1, 15 and 31, respectively. Its stellar magnitude varies between 1·6 and −1·5, the visible portion of its illuminated disk increasing from 0·173 to 0·959 and its distance from the earth varying from 66 to 121 million miles. As already noted, it approaches the moon very closely on July 18. Venus is visible in the early morning hours, rising at 2h. 45m., 3h. and 3h. 35m. at the beginning, middle and end of the month, respectively. The visible portion of the illuminated disk remains almost the same, the variation being 0·955–0·988 and the stellar magnitude changing from −3·3 to −3·4. Mars sets less than an hour after sunset on July 1 and is too close to the sun during the month for favourable observation. Jupiter, which is in conjunction soon after the end of the month, is too close to the sun for favourable observation. Saturn sets at 1h. 05m., 0h. 10m. and 23h. 05m. on July 1, 15 and 21, respectively, its stellar magnitude being 0·7–0·8, and its distance from the earth increasing from 863 to 905 million miles. Only one star of magnitude brighter than 6 is occulted in July: 4744 reappears on July 11d. 0h. 13·5m., + 1°, mag. 5·6 (observation being made at Greenwich). The sun is in aphelion on July 4.

## Announcements

PROF. J. H. OORT, professor of astronomy in the University of Leyden, has been elected a *correspondant* for the Astronomy Section of the Paris Academy of Sciences in succession to Sir Harold Spencer Jones, recently elected a foreign associate of the Academy.

PROF. L. DUDLEY STAMP, professor of social geography in the London School of Economics and Political Science, has been awarded the honorary degree of LL.D. by Clark University, Worcester, Massachusetts. The Graduate School of Geography at Clark University, now headed by Prof. S. Van Valkenburg, has long held a leading position in the United States, and for the past thirty years has published the quarterly journal *Economic Geography*.

SIR ROGER DUNCALFE, president of the British Standards Institution, has been elected president of the International Organization for Standardization and will hold the office for three years from January 1 next. Besides his national and international work on industrial standards, Sir Roger is closely connected with chemical industry, being chairman of British Glues and Chemicals, Ltd.

THE Shell Petroleum Co., Ltd., is to award annually to students in Canada two postgraduate scholarships in science or engineering similar to those already given by the Company to students in other countries of the British Commonwealth. The scholarships are worth £750 a year for two years of study in the United Kingdom leading to a higher degree. The first two awards have now been made to the following for study as shown: T. P. Schaefer (University of Manitoba), physical chemistry in the University of Oxford; and G. B. Chadwick (University of British Columbia), nuclear physics in the University of Cambridge.

AN exhibition of radiological defence instruments will be held during June 28–29 in the Palais de Chaillot, Paris, the headquarters of the North Atlantic Treaty Organization, in conjunction with the forthcoming first session of the Civil Defence Committee. Several countries will be showing their equipment, and the British contribution to the exhibition is considerable, with sixteen individual manufacturers participating. A catalogue of the British exhibits, printed in English, French, German, Spanish and Greek, has been prepared and is available on application to R. H. Cooke, X-Ray Division, Philips Electrical, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, from whom further information can be obtained.

AN exhibition of scientific instruments and apparatus of Continental manufacture is being held by Hudes Merchandising Corporation, Ltd., Charter House, 52 Gloucester Place, London, W.1, during June 28–July 9. Among the exhibits are balances by Sartorius-Werke, a flame photometer from Dr. Lange of Berlin, a complete range of electrophoresis and chromatographic apparatus from L.K.B. Produkter of Stockholm, the Sjöstrand ultramicrotome, some new electrically heated porcelain apparatus, glass apparatus by Schott and Genossen, interference filters and a range of Zeiss microscopes and accessories.

# PERSONAL FACTORS IN ACCIDENT PRONENESS*

STUDIES of accident proneness are usually either statistical or psychological. The statistical studies have inherited common aims and methods from the pioneer work of Greenwood and Woods[1]. The psychological studies have been diverse in aim, ranging from attempts to predict the accident prone by æstheto-kinetic skill test performance, through other investigations of a laboratory type seeking to define the behaviour inadequacies responsible for accidents, to clinical assessment of various aspects of the personality of multiple accident-prone individuals. Dr. J. A. Smiley's work belongs to the last-named class, although he gives due place to earlier work along the other approaches. He has made full use of his position as medical adviser to an aircraft-manufacturing company to study the accident histories of 6,450 men, and to examine in detail eighty-seven men classified as accident prone, and a random control group of a hundred normal men.

His thesis may briefly be stated—accident-prone individuals are usually emotionally disturbed, with associated hypothalamic misfunction which, it is tentatively suggested, produces minor imbalance of adrenalin and acetylcholine with concomitant behaviour disturbance. This thesis needs to be examined both in the light of the evidence he presents, and in respect of other studies.

There can be no doubt that a large proportion of his eighty-seven cases were emotionally disturbed. The evidence, presented soberly and cautiously, may almost be described as overwhelming. The case-histories are illuminating; classification on Culpin's scale (with a high degree of care exercised against possible observer bias) shows that 72 per cent of the accident group exhibit emotional disturbance of a marked degree, against 8 per cent of the normals. The accident-prone individuals also show 'anxiety' sweating in interview, albumin in the urine specimens collected during medical examination, a seven-fold increase in peptic ulcer incidence, and a more than four-fold increase in incidence of other medical symptoms. There can be little doubt as to the accuracy of the psychiatric diagnoses of these men.

The problem remains, however, whether these men may adequately be described as accident prone. Dr. Smiley is cautious in pointing out that his conclusions may only apply to men engaged on similar work and (as he specifically states) would not apply to road accidents. His introductory statistical observations (which are, unfortunately, marred by errors—his tabulations of observed accident frequency give a total incidence of 13,584, against a quoted 14,498, the latter figure being used for the theoretical distributions) do not completely comply with the canons of statistical investigation. Although the men all work in shops of roughly equivalent risk per hundred thousand man-hours, no check has been made of each individual's actual exposure, which, of necessity, will vary with the total number of hours worked. It is also very likely that there are large differences in actual risk due to differences in work done within the larger occupation groups. The eighty-seven cases picked out are, however, so removed from their fellows that these points are probably of minor importance. A more serious objection is that only minor injuries are considered. To some extent this must have been inevitable, as apparently only 1 per cent of injuries reported involved absence of more than one day. Greenwood and Woods's dictum that the law of a distribution will not in general be affected by the consequences of the result is quoted in extension of this use. But the correlation between minor and major accidents, though positive, is not usually very large, and accident proneness, as an important problem, concerns those incidents with more severe medical, human and economic sequelæ. Dr. Smiley's accident group attended the medical room for accident injury treatment approximately six times as often as average. They also attended for other medical purposes approximately two and a half times more than normal. Taken in consideration with the sweating, albuminuria and peptic ulcer incidence, the main conclusion to be drawn is that proneness to report minor injury can be added to the list of other known clinical signs of emotional disturbance. This is valuable; but when Davis[2] has reported that a group of accident-prone coalminers (who had sustained many 'disabling' accidents) showed no similar symptoms, it would suggest that accident proneness, as distinct from proneness to attend the surgery whatever the reason, has still to be described in psychological or psychiatric terms.

J. W. Whitfield

* Substance of the Milroy Lectures of the Royal College of Physicians of London, given by Dr. James A. Smiley on Feb. 8 and 10, 1955.

[1] Greenwood, M., and Woods, H. M., "The Incidence of Industrial Accidents, with Special Reference to Multiple Accidents". (Medical Research Committee, Industrial Fatigue Research Board Report No. 4.) (London: H.M.S.O., 1919.)

[2] Davis, D. R., *Quart. J. Exp. Psychol.*, **1**, 136 (1949).

# SECONDARY ELECTRON EMISSION

A COLLOQUIUM on "Secondary Electron Emission", sponsored jointly by the Institute of Physics and the Physical Society as one of a series of meetings on electron physics, was held in the lecture theatre of the Institute on March 1, when eight papers were read and discussed. This report summarizes first the papers on secondary emission yield, on energy losses and on depth of penetration of electrons, and is followed by a résumé of the talk by Prof. H. Fröhlich (University of Liverpool), who spoke on the quantum theories of secondary emission. The succeeding papers deal with phenomena exhibited by specific targets.

S. Rodda (Edison Swan Electric Co., Ltd., Enfield) spoke briefly on universal curves for secondary emission yield, a subject in which we are greatly indebted to Bruining and Jonker. The formulæ proposed assumed $\delta$ to be of the form

$$\delta = \frac{aV^n}{1 + bV^m}$$

in which the relative yield curve would be

$$\Delta = \frac{\frac{m}{m-n} W^n}{1 + \frac{n}{m-n} W^m}$$

with $\Delta = \delta/\delta_m$, $W = V/V_m$.

Kadyshevich has given an equation of the form

$$\Delta = \frac{2W}{1 + W^2}$$

but this falls away too quickly when $W$ is high. Good agreement with the experimental results collected by Jonker exists if $\Delta$ is put equal to

$$\frac{3W}{1 + 2W^{3/2}}$$

or with the results of Brophy if

$$\Delta = \frac{2W^{1/2}}{1 + W}.$$

The latter also matches well a complicated equation for $\Delta$, derived by Rodda, assuming three things: the depth of penetration of primaries proportional to their energy at incidence; the probability of creation of a secondary electron inversely proportional to the primary velocity at depth $x$ to $(x + dx)$; and the probability of escape from a depth $x$ to be proportional to $x_0/(x_0 + x)$. (It may be remarked that Dr. Bruining's results quoted below do not invalidate the first assumption, if reflected primaries from the molybdenum substrate return to a large minimum depth from which the ejection of secondaries is detectable.)

The second paper, on the secondary-emission coefficient of the elements, was by D. A. Wright (Research Laboratories, General Electric Co., Ltd., Wembley), who first sketched the attempt made by Sternglass in 1950 to relate $\delta_m$ to the position of the element in the periodic table. Wright has replotted the available values of $\delta_m$ against atomic number, and the graph clearly shows a break at sodium which he expected, and confirms the rise at the end of the second part of the long period which was shown by Sternglass. "This rise corresponds with a similar rise in both work function and ionization potential." Wright has been particularly interested in the correlation of $\delta_m$ with work function, and showed that $\delta_m$ increases with $\varphi$ with a definite, almost linear correlation between their values. Finally, it was shown that better correlations appear if one plots work function and secondary emission against the reciprocal of the distance ($d_a$) of closest approach of the atoms in a solid, instead of against the inverse cube root of the atomic volume. The values of $\delta_m$ and $\varphi$ then follow "one main line, a parallel line for the second period and higher lines for the second parts of the long periods". The behaviour can be understood if the scattering and energy-losses of the secondary electrons are, in fact, independent of $d_a$.

In his paper on the characteristic energy-losses of electrons in solids, Dr. D. Gabor (Imperial College of Science and Technology, London) reported on the collective interaction of metal electrons with fast electrons, first suggested by D. Bohm and D. Pines. This process can be conceived in much the same way as the interaction of X-rays with solid lattices in Bragg's interpretation, that is to say, as reflexions by the Fourier components of electron density.

Experiments recently carried out by D. Gabor and G. W. Jull have supplied evidence that the characteristic energy-losses first observed by Rudberg, Farnsworth and, in particular, by Ruthemann are due to collective interaction. The losses in solid layers of gold 100–200 A. thick were compared with stratified sheets built up in layers of 30 A. each, with thin layers of carbonaceous contamination between. The stratified layers did not show characteristic losses, so that these cannot be due to interactions with single atoms. The theory of collective interaction explains this, because in stratified sheets only those vibration modes exist which give zero current at the boundary at every stratum, and so there are fewer vibrational modes than in a solid layer. The experiments suggest that plasma waves with wavelengths less than 30–50 A. are strongly damped.

The next paper, by Dr. H. Bruining (Philips Research Laboratories, Eindhoven), dealt with some experiments on the depth of penetration of electrons in thin beryllium layers. The experiments were undertaken to find the range of primary electrons by measuring the secondary emission yield of targets consisting of different components, and in the particular experiments described, which were carried out by Nienhuis of the Philips Laboratories, successful results were obtained by evaporating layers of beryllium on to a molybdenum substrate. It is essential that the secondary emission yields of the two materials chosen shall differ widely, and this is fulfilled, since $\delta_m$ for beryllium is 0·6 and $\delta_m$ for molybdenum is 1·3. At first the secondary emission yield rises when a thin, presumably monatomic layer of beryllium is evaporated on to the molybdenum; but with thicker layers $\delta$ becomes characteristic of the evaporated metal below some critical voltage $V_p$ of bombardment, while above $V_p$ there is a divergence. $V_p$ varies with the time of evaporation and therefore with the thickness of the deposited metal. At first sight it would seem that the thickness of the metal is that which is just penetrated by primary electrons of energy $eV_p$. The curve for the thickness $d$, plotted against $V_p$, can be represented by the square law equation $d = V_p^2/a$, where $a$ has the value $0{\cdot}8 \times 10^{12}$ V.$^2$/cm., in remarkable agreement with the value $0{\cdot}75 \times 10^{12}$ V.$^2$/cm. determined by Whiddington for beryllium.

Calculations which Dr. Bruining gave showed, however, that the absorption of secondary electrons originating in the molybdenum would be so strong in the beryllium layer that none could reach the target surface; the observed rise in $\delta$ should be ascribed to the reflexion of fast primaries from the interface, or to the enhanced generation of secondaries in the beryllium layer which the reflected primaries would cause. In the latter case, too, only the additional secondaries produced in a very thin surface layer of the beryllium could escape. Thus the argument shows that the incident electrons must have travelled back and forth through the beryllium layer, which means that the range was twice the thickness of the layer and so $a$ equals $0{\cdot}4 \times 10^{12}$ V.$^2$/cm. instead of $0{\cdot}8 \times 10^{12}$ V.$^2$/cm.

The results were compared with those of Copeland in 1940, when targets of aluminium covered with platinum were investigated, and showed a linear relation between depth of penetration and $V_p$ up to 500 V., tending to a parabolic shape at high values of $V_p$. The difference may be due to the difference in atomic structures between the simple beryllium and the more complicated shell of platinum, where more electrons could interact with a primary electron as its energy is increased.

When Prof. Fröhlich spoke on the theory of secondary electron emission from solids, he made it clear that none of the recent attempts to develop a theory of secondary emission from solids is physically correct. It is not permissible to represent the wave functions of the valency electrons by plane waves when the collision processes involve large changes in

energy. Prof. Fröhlich proposed to use the Weizacker–Williams (1935) method to calculate the rate of loss of energy of a particle in a solid. The primary particle is replaced by a moving point charge $e$, having velocity $v_0$, and its time-dependent field is developed in its Fourier components with respect to time. If the optical properties of the solid are expressed in terms of a complex dielectric constant

$$\varepsilon(\omega) = \varepsilon_1(\omega) + i\varepsilon_2(\omega)$$

it is shown that (cf. Fröhlich and Platzmann, 1953)

$$-\frac{dW}{dt} = \frac{2e^2}{\pi v_0}\int_0^\infty \frac{w\varepsilon_2(\omega)}{\varepsilon_1^2(\omega) + \varepsilon_2^2(\omega)}\, x\, K_0(x)\, K_1(x)\, d\omega$$

where $W$ = energy of the particle, $v_0$ = velocity of the particle, $K_0(x)$ and $K_1(x)$ are modified Bessel functions of the second kind, of order zero and 1, and $x = \omega\rho_{min.}/v_0$, $\rho_{min.}$ being the smallest value the collision parameter can take. This value has to be determined from independent considerations and usually occurs in the final result only logarithmically.

Further calculations (which can be reproduced in this article only in condensed form) show that there must be a close connexion between photoelectric and secondary emission in a solid. Let

$$P(\mathbf{v},\omega)\, dv_x\, dv_y\, dv_z$$

be the rate of emission of photoelectrons with velocity $\mathbf{v}$ in a range $dv_x\, dv_y\, dv_z$ if the electric displacement in the solid is such that its square is $D_\omega^2 d\omega$ in a range near $\omega$. Then a function $f(\mathbf{v},\omega)$ can be found such that

$$P(\mathbf{v},\omega) = f(\mathbf{v},\omega)D_\omega^2$$

and if $Q(\mathbf{v})\, dv_x\, dv_y\, dv_z$ is the rate of emission of secondary electrons of velocity $\mathbf{v}$ in the range $dv_x\, dv_y\, dv_z$, it follows that

$$Q(\mathbf{v}) = \int f(\mathbf{v},\omega)D_\omega^2 d\omega.$$

Now primary electrons of velocity $v_0$ crossing the surface at the rate of $n$ per second per unit surface area create an electric displacement in an (isotropic) solid such that

$$D_\omega^2 d\omega = \frac{2}{\pi}\frac{e^2}{v_0^2}\, n\, d\omega\, x\, K_0(x)\, K_1(x)$$

so that $Q(\mathbf{v}) = \frac{2}{\pi}\frac{e^2}{v_0^2}\, n \int_0^\infty f(\mathbf{v},\omega)\, x\, K_0(x)\, K_1(x)\, d\omega.$

To turn now to the phenomena exhibited by fabricated targets, Prof. J. D. McGee (Imperial College of Science and Technology, London) read an interesting paper contributed by Prof. W. G. Shepherd and P. Wargo (University of Minnesota) on the preparation of thin-film magnesium oxide secondary-emission targets and some of their properties. In their laboratories a secondary-emission ratio of the order of 12 at 500–700 V. primary energy has been obtained by baking the electrodes *in vacuo* at a pressure less than $10^{-4}$ mm. of mercury and then heating the alloy to 750° C. brightness in dry oxygen at a pressure of 10–20 microns.

The silver does not directly contribute to the properties of the ultimate magnesium oxide film; but during the preparation it governs the diffusion of magnesium to the surface, and the detrimental counterflow of oxygen diffusing into the silver, where it would react internally with the magnesium to form magnesium oxide. The magnesium diffusing to the surface may be oxidized there, or with low oxygen pressure lost by evaporation. It is possible to inhibit the diffusion of oxygen into the alloy by plating thereon a layer of nickel one micron thick, and Rappaport has successfully used gold. Satisfactory results were also obtained with a dry carbon dioxide atmosphere. The authors also considered the effects of evaporation materials from an oxide-coated cathode; by using a radioactive tracer technique it was found that barium was evolved about ten times faster than strontium, almost certainly as barium oxide. An experimental system was then described whereby barium oxide can be evaporated on to a silver magnesium target, the thickness determined by a tracer method, and the secondary emission yield measured.

With very thin layers of barium oxide on magnesium oxide, the effect is to increase $\delta$, which becomes a maximum when the layer is between one and two molecules thick. When $\delta$ is plotted against evaporated film thickness, the curves exhibit a break for a thickness of thirty molecular layers for each energy, which suggests that the depth of escape of the secondary electrons controls the yield rather than the depth of penetration of the primary electrons. In further studies on thin magnesium oxide films it was concluded that an overlayer of barium oxide would protect magnesium oxide from erosion under electron bombardment, and as an example it was shown that the time required for $\delta$ to fall to 80 per cent of its original value rose from 8 hr. with the uncoated magnesium oxide target to 190 hr. with a similar target with a barium oxide coating eight molecular layers deep.

Dr. J. Woods (Research Laboratories, General Electric Co., Ltd., Wembley) reported on the studies he had carried out on the mechanism of secondary-emission decay processes. Barium oxide films were chosen since $\delta$ decays rapidly under electron bombardment and the physical properties of barium oxide are well known. Experiments show that the oxide decomposes under bombardment, and that the free barium formed is responsible for the reduction in $\delta$; in fact, the oxygen moves outwards towards the surface while an excess of barium accumulates in the penetrated region of the oxide. A film in which an excess of barium is created in this way can be brought to give its original $\delta$ by oxidation. The reason why an excess of barium is detrimental is due to the coagulation of barium into colloidal particles which act as very efficient electron traps.

Thick evaporated films of barium oxide exhibit a blue luminescence when bombarded with 240-V. electrons, and when $\delta$ decays the luminescence decays also. The behaviour of a zinc-cadmium sulphide phosphor under electron bombardment shows many analogies, and it is suggested that the phenomenon of electron burn is due to colloidal metal formed in the bulk of the sulphide.

In a final short paper, R. M. Payne (Associated Electrical Industries, Aldermaston) described electron diffraction investigations on the electropolished surfaces of beryllium–copper and a beryllium–copper alloy containing cobalt. These materials had been used for a demountable secondary electron multiplier. An extremely compact multiplier with beryllium–copper electrodes was shown by Dr. R. H. M. Lamb (Cavendish Laboratory, Cambridge) as one of many possible examples of the technical importance of "secondary electron emission".

S. Rodda

# PEPTIDE CHEMISTRY

## CHEMICAL SOCIETY SYMPOSIUM

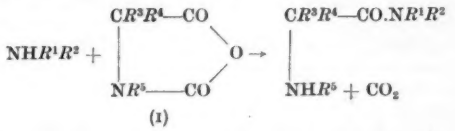
ON the occasion of the recent anniversary meetings in London of the Chemical Society, a symposium on peptide chemistry, arranged by Prof. D. H. Hey, was held on March 31 at the Royal Institution. The symposium consisted of five papers, two on physico-chemical aspects of the problem (Prof. H. D. Springall in the chair), and three on organic chemical aspects (Prof. Hey in the chair). A full account of the symposium will be issued as a special publication of the Chemical Society. The proceedings were opened by Prof. W. Wardlaw, president of the Chemical Society.

The first paper was by Prof. K. Linderstrøm-Lang (Carlsberg Laboratories, Copenhagen), who described some of his recent work on deuterium exchange between peptides and water. From earlier work it appeared likely that the rate of deuterium exchange in peptide systems would vary with the accessibility of the replaceable hydrogen atoms and the extent to which they are involved in hydrogen-bonding. In the present work, the quantitative study of rates of deuterium exchange has been applied to peptide systems of varying complexity and the results correlated with the structure of the peptides.

The experimental techniques were described. These depend on cryosublimation at −60° C., and density determinations, in the gradient tube. The results are as follows: Single-chain peptides, lacking intra-chain disulphide bridges, undergo immediate and complete exchange at 0° (alanylglycine, leucyltriglycine, oxidized insulin *A*-chain, oxidized ribonuclease). In the case of ribonuclease, this 128-residue single-chain peptide has four intra-chain disulphide bridges and, at *p*H 4·7, contains 245 exchangeable hydrogen atoms, 123 in side-chains and 122 in the backbone. About two hundred atoms (all those in the side-chains and about seventy-five in the backbone) undergo very rapid exchange. The rest require five hours at 40° for complete exchange, presumably due to the stabilizing of hydrogen-bonded structures by the disulphide bridges. In the case of insulin, the monomer has the two-chain (21 and 30 residues) structure with two inter-chain and one intra-chain disulphide bridges. There are 91 exchangeable hydrogen atoms, 43 in the side-chains and 48 in the backbone. 61 atoms (all those in the side-chains and 18 in the backbone) undergo very rapid exchange, 7 somewhat slower exchange, and 23 very slow exchange. It is suggested that the 23 very sluggish atoms are in the backbone sections between the inter-chain bridges.

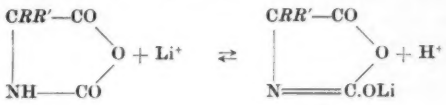
In the discussion of this paper, Dr. K. Schlögl (Vienna) asked if the exchange method could be used for studying a postulated enolization of peptide bonds in alkaline solution. Prof. Linderstrøm-Lang said that the exchange reaction, in some cases, is faster in alkaline solution, but he did not feel this to be due to enolization. Dr. D. Crowfoot Hodgkin (Oxford) pointed out that the 'loop' in insulin is stereochemically favourable for β-pleated sheet and α-helix peptide configurations and suggested the possibility of an exchange study of this. Dr. J. I. Harris (Copenhagen) directed attention to the fact that species variation of amino-acid composition of insulins is confined to the 'loop'. Dr. F. Sanger (Cambridge) confirmed this and asked if the difference between pig and sheep insulins (alanine for threonine and glycine for serine) could be detected by exchange methods; Prof. Linderstrøm-Lang thought this might be possible.

The second paper, by Dr. C. H. Bamford (Courtaulds, Maidenhead), dealt with recent work with Dr. D. G. H. Ballard on the mechanism of the N-carboxy-α-amino-acid anhydride synthesis of polypeptides. In the normal polymerization, the propagation reaction is of the type:

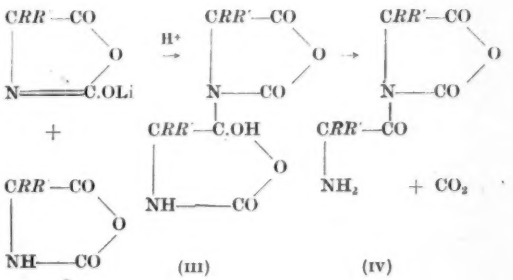


(I)

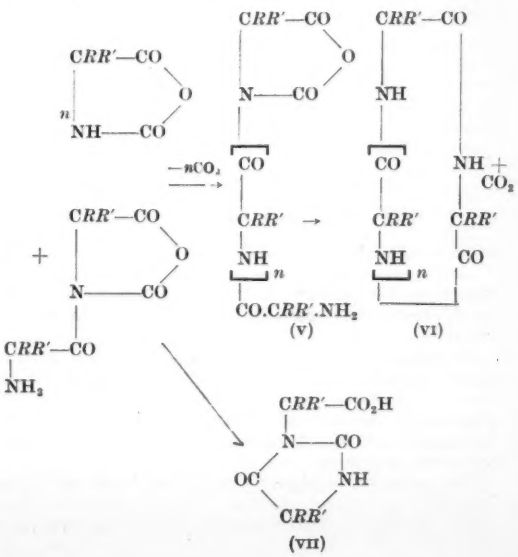
the product then reacting with more carboxy-anhydride. Recently, however, reactions of other types have been observed: notably those of (I; $R^5$ = H) with sodium and lithium ions in polar solvents to give cyclic polymers (VI) together with some of the 3-hydantoinylacetic acid (VII). It is suggested that these reactions proceed as follows:



(II)



(III) (IV)



(V) (VI) (VII)

The grounds for these postulates are: (1) the nature of the products; (2) the essential nature of the NH group in the carboxy-anhydride; (3) the strong inhibiting effect of acids; and (4) the agreement between the kinetic data calculated from these equations and those actually observed.

The work described is a kinetic study (by rate of evolution of carbon dioxide) of the reactions of the anhydrides of N-carboxyl-DL-phenylalanine and γ-benzyl-N-carboxy-L-glutamate in nitrobenzene/N-methylformamide solution in the presence of sodium β-phenylpropionate. The kinetic studies and an analysis of the molecular weights of the reaction products support the view that "the essential feature of the salt-initiated polymerizations of the carboxy-anhydrides is the formation of a complex of type (II), which behaves as an activated form of the carboxy-anhydride. It initiates polymerization by reacting with the carboxy-anhydride to yield bifunctional intermediates, which couple and also enter into a growth reaction involving the complex. The initial rates of reaction are consequently very high, and the degrees of polymerization in general much greater than would be expected from the ratio [carboxy-anhydride] : [initiator]. In these respects the reactions differ fundamentally from the simple polymerizations catalysed by primary or secondary bases".

In the discussion on this paper, Dr. K. Schlögl criticized the suggested mechanism on several grounds, and Dr. Bamford gave a detailed reply to this criticism. Dr. J. A. Stock (London) asked if initiation by the sodium salts of amino-acids would yield cyclic polypeptides; Dr. Bamford felt that yields would be lower than with lithium chloride initiation.

In the third paper, Prof. V. du Vigneaud (Cornell University Medical College, New York) described his studies on the synthesis of cystine peptides, dealing especially with the reactions in liquid ammonia. These studies, extending over the past twenty-five years, have recently culminated in the brilliant synthesis of the peptide pituitary hormone, oxytocin. The following reactions, critically important for peptide work, have been achieved in liquid ammonia solution in the presence of sodium:

$$\text{Cy—S—S—Cy} \rightarrow 2\text{Cy—SH (as Cy—SNa)} \quad (1)$$

$$\text{Cy—SH} \xrightarrow{\varphi\text{CH}_2\text{Cl}} \text{Cy—S.CH}_2.\varphi + \text{NaCl} \quad (2)$$

$$\text{Cy—S.CH}_2\varphi \rightarrow \text{Cy—SH} + \text{CH}_2.\varphi \quad (3)$$

$$R\text{—O.CH}_2\varphi \rightarrow R\text{—OH} + \text{CH}_2.\varphi \quad (4)$$

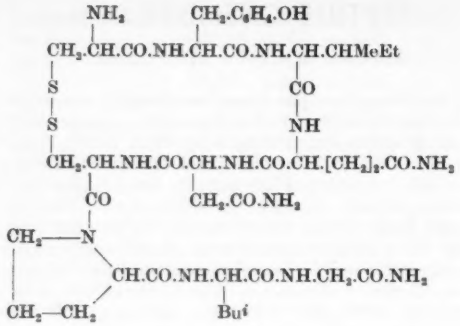
$$\text{Tos.NH—}R \rightarrow p\text{-CH}_3.\text{C}_6\text{H}_4.\text{SH} + \text{NH}_2\text{—}R \quad (5)$$

$$\varphi.\text{CH}_2.\text{O.CO.NH—}R \rightarrow \varphi.\text{CH}_3 + \text{CO}_2 + \text{NH}_2\text{—}R \quad (6)$$

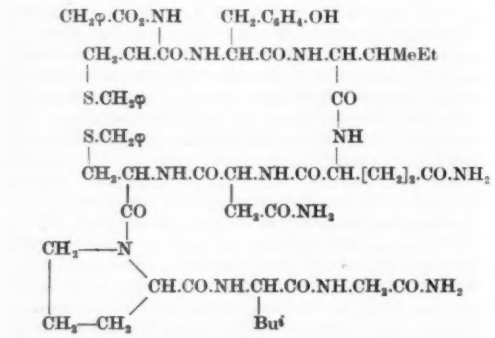
Moreover, favourable conditions have been devised for the reversal of reaction (1) by aeration in aqueous solution.

All these reactions, except (4), were used in the oxytocin synthesis. The first major application of these techniques was in the 1936 synthesis of glutathione, which had been synthesized in 1935 by Harington and Mead without resource to the liquid ammonia reactions.

The isolation of highly purified oxytocin and subsequent degradative studies, 1949–53, indicated the cystine bridge-cyclized nonapeptide triamide structure (I).




(I)



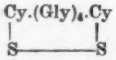

(II)

The compound (II) was successfully synthesized, the N- and S-protecting groups removed ($Na/NH_3$) and the disulphide bridge formed by air oxidation, yielding structure (I). The synthetic material was rigorously compared with natural oxytocin and found to be identical with it, in chemical, physical and physiological properties.

Sir Charles Harington opened the discussion on this paper with a tribute to Prof. du Vigneaud, and asked if a synthetic approach to insulin might be envisaged. Prof. du Vigneaud, remarking on the occurrence of the 20-membered loop in both insulin and oxytocin, said: "One has a right to dare to think that insulin could be synthesized—but it is of another order of magnitude of difficulty".

Prof. H. N. Rydon (Manchester) spoke briefly of his work on the air oxidation of the five peptides HS.Cy.$(Gly)_n$.Cy.SH ($n$ = 0, 1, 2, 3, 4). With $n$ = 0 and 1, the main products are antiparallel cyclic dimers

and with $n$ = 4, the cyclic monomer

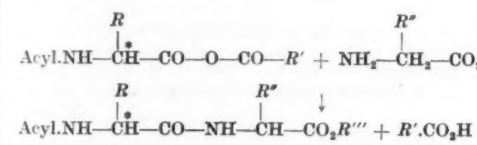



containing the 20-membered ring.

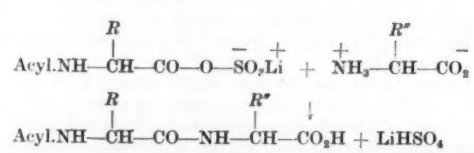
Dr. J. I. Harris (Carlsberg Laboratory, Copenhagen) read the fourth paper, describing his studies on C-terminal residue identification with carboxypeptidase. He outlined the experimental procedures and discussed the results obtained from insulin, somatotropin, α-corticotropin and tobacco mosaic virus. In general, cleavage is fastest with C-terminal aromatic amino-acids, very slow with an acidic or basic C-terminal residue and does not occur with C-terminal proline. Thus with the *B*-chain of insulin which has the terminal sequence . . . Pro.Lys.Ala., the alanine is released by carboxypeptidase, but reaction stops at that stage. With α-corticotropin, however, with the terminal sequence . . . Pro.Leu. Glu.Phe., the last three residues are split off in sequence. The summarized individual results per mole are: insulin gives one alanine and one asparagine, somatotropin, two phenylalanine; α-corticotropin, one phenylalanine, then one glutamic acid, then one leucine; tobacco mosaic virus, 2,900 + 100 threonine. The C-terminal sequences do not seem to be of critical importance for biological function. Dr. Harris, acknowledging the power of the enzymic methods, notably their very gentle experimental conditions, pointed out the need for a chemical method of study of C-terminal residues.

In the discussion, Prof. C. Fromageot (Paris) pointed out that ovomucoid is inert to carboxypeptidase but yields phenylalanine with lithium aluminium hydride. Dr. Harris felt that this must arise from some non-terminal fission. Dr. K. Schlögl advocated the Akabori hydrazine method for chemical study of C-terminal residues, to which Dr. Harris indicated the objections to a chemical method involving the complete degradation of the peptide chain.

Dr. G. W. Kenner (Cambridge) read the final paper, on mixed anhydride syntheses of peptides. He traced the development of the technique based on the reaction



from the work of Wieland, Vaughan and Boissonas ($R' = \varphi$ originally, then = Bu$^t$, then = OEt). There is grave danger of racemization at C* and there are difficulties in the removal of $R'''$ (though these have been largely overcome using $R''' = CH_2\varphi$ and removing it by hydrogenolysis). To avoid these difficulties, Dr. Kenner has developed the use of mixed anhydrides of acylamino-acids and sulphuric acid, which will react, with very slight racemization, with free amino-acids and peptides in aqueous dimethylformamide solution



In the discussion, Dr. G. T. Young (Oxford), commenting on the importance of avoiding racemization, reported that, in the condensation of acetyl-L-leucine with glycine, ethyl ester configuration is retained using the Curtius azide method but lost using the Goldschmidt phosphorazo method. Prof. J. Baddiley (Newcastle upon Tyne) asked if the sulphuric anhydride method could be used to link an amino-acid to an amide $NH_2$ group, and to this Dr. Kenner replied that he felt it to be unlikely.

H. D. SPRINGALL

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# CAMBRIDGE OBSERVATORIES

## REPORT FOR 1954

THE report of the Observatories Syndicate of the University of Cambridge for the year ending September 30, 1954*, is divided under the following headings: reconstruction and re-equipment; solar research; stellar photometry; other investigations; optics; buildings and grounds; lectures; and papers accepted for publication. The installation of the new 17–24-in. Schmidt telescope has been completed and tested extensively, and the original driving error—approximately a sine wave of total 6″—has been removed. The old Common 36-in. reflector has been dismantled and returned to the Science Museum, South Kensington, and the foundations for the new 36-in. reflector are ready for the telescope, which was expected to be delivered in December.

A great portion of the report dealing with solar research is devoted to the observations of the total solar eclipse of June 30, 1954, details of which have been already given in various publications. Plans were made, and preparations commenced, for observation of the total eclipse of June 20, 1955, when Dr. D. E. Blackwell will continue the work which he carried out at the 1954 eclipse—photographing the corona and zodiacal light, etc., to make accurate photometric measurements; a Sunderland flying-boat will be used, flying from the Fiji Islands over the Pacific Ocean (*Nature*, June 11, p. 1018). Prof. R. O. Redman, the director of the Observatories, and Dr. Z. Suemoto have completed the study of chromospheric line-widths, based on spectrograms obtained at the 1952 eclipse. Self-absorption and Stark effects, which are of greater importance than had been formerly supposed, having been taken into account, they have shown that the line-widths in the hydrogen Balmer series are consistent with a kinetic temperature not exceeding 10,000° K. and also that a model at 6,000° K. would represent the measures almost as well as at 10,000° K. In addition to other solar work, reference may be made to the critical examination in the 30-ft. spectrograph of two large, good-quality gratings, both with 600 lines per mm., one from Bausch and Lomb, of ruled area 20 cm. × 15 cm., and the other from the Mount Wilson Observatory, with ruled area 20 cm. × 13·7 cm.; the latter is on loan to the Observatories and "gives quite remarkable performance, theoretical resolving power being attained in the fifth order". It is to be embodied in a Babcock magnetograph for recording weak magnetic fields and Doppler effects on the sun's surface.

Under the heading of stellar photometry, it is very satisfactory to know that the Royal Astronomical Society has decided to publish in its "Memoirs" the results of the +15° Selected Areas programme of

* University of Cambridge. Report of the Observatories, for the year ending September 30, 1954. Pp. 4. (Cambridge: University Press, 1955.)

stellar photometry, thus obviating the difficulties encountered in finding the necessary funds. Investigations on the performance of the 17–24-in. Schmidt telescope, in which Prof. H. A. Brück, director of the Dunsink Observatory, co-operated by allowing the Eicher photometer to be used for measuring test plates, have shown that with a filter removing the ultra-violet below about 4000 A. star images can be measured satisfactorily to mag. 18 photographic on a 30-min. exposure (Ilford 'Zenith' plate).

Under the heading of "Other Investigations", an account is included of the test and adjustment work on the Schmidt telescope. To acquire familiarity with the instrument, a programme of photography of discrete radio sources has been undertaken, using positions provided by the Cavendish Laboratory's radio-astronomy group, and about a hundred photographs have been obtained. Up to the present, the results have not been encouraging, and it seems possible that most of these sources cannot be profitably photographed with this telescope.

In the section on optics, reference may be made to the experimental work which has been continued on the production of mirrors relatively free from thermal distortion, which would be useful for solar work, and experiments are being made with thin glass bonded with plastic glue to a mild-steel support. The assistance of the firm of Aero Research, Ltd., is acknowledged in the preparation of these disks. An investigation into the problem of assessment of optical images has been made by Dr. E. H. Linfoot and Dr. P. B. Fellgett, and a paper on the subject will appear later (*Phil. Trans. Roy. Soc.*).

During the year, twenty-four lectures on the sun were given by Prof. Redman; sixteen on optical aberration and eight on diffraction theory of the optical image by Dr. E. H. Linfoot; twenty-four on general astrophysics by Dr. D. E. Blackwell; and fifteen on elementary electronic techniques and fifteen on spherical astronomy by Mr. G. G. Yates. The Observatory Club held twelve colloquia during the year, at which the speakers included Prof. W. M. H. Greaves, Dr. J. Houtgast, Mr. G. M. Sisson and Dr. P. A. Sweet. Fifteen papers were accepted for publication in various scientific journals during the year.

## MALAYAN ANNONACEAE

J. SINCLAIR has contributed to our knowledge of an important family of tropical flowering plants in his "Revision of the Malayan Annonaceae" (*Gardens' Bull.*, **14**, 2, 149; 1955; Govt. Printing Office, Singapore; 10 dollars).

The Annonaceae are confined mostly to moist tropical lowland forests, being more plentiful in the Old World than in the New. In the present revision, there are thirty-eight genera, comprising 198 native and five cultivated exotic species, making a total of 203, together with seventeen varieties.

Points of difference between the present and earlier classifications are indicated. The main taxonomic section begins with an account of the general characters of the family, including fairly comprehensive and detailed references to the main morphological characters; here special attention is paid to the petals, which are stated to be of greater diagnostic value in this family than any other organ. "They show such a wonderful diversity in size and form that it may be said the peculiarities of the family are exhibited in its petals." They are, in fact, the main basis of classification in this group of flowering plants.

Because in the Annonaceae there are orderly progressions leading from one group to another, the constituent tribes are rather ill-defined, with overlapping characters. The author has summarized the inferences of evolutionary import as follows: "There are in the family very noticeable evolutionary trends which have a bearing on classification. Since evolution proceeds neither evenly nor at the same rate, we find genera advanced in some characters and primitive with regard to others. There is a tendency to proceed from simplicity to complexity, for example, from simple petals with no distinction between blade and claw to the complex dome-shaped petals of the Mitrephoreae with their long narrow claws and united blades; from the clumsy stamen with a great deal of connective tissue to a more precise form with a filament and greater development of the pollen sacs. There is a tendency for reduction from many seeds in two rows to a single better nourished seed and also a union of parts to give more protection. The petals become united and the stamens become fewer. The greatest advance of all is where the carpels unite to form a 1-celled ovary with parietal placentation and there is thus a division of the family into two subfamilies, the Annonoideae (apocarpous forms mostly) and the Monodoroideae with a 1-celled ovary, parietal placentation and gamopetaly (Isolona and Monodora)".

## GRAFTING EXPERIMENTS BETWEEN THE TOMATO VARIETIES, GOLDEN APPLE AND OXHEART

By A. J. BATEMAN*

Cytogenetics Laboratory, Christie Hospital and Holt Radium Institute, Manchester 20

IN a recent issue of *Nature*[1], reference was made to tomato-grafting experiments by Dr. L. Felföldy of Hungary, whose results have been published in English[2]. A special feature of the work was that spectacular results had been obtained with the varieties Golden Apple and Oxheart, which are known in Britain. In repeating this experiment, a closer parallel than hitherto should have been possible between Michurinist and Western experimenters. In a letter to Dr. Felföldy, I expressed my desire to repeat his work, whereupon I received seed of his own stocks. It is this identity of experimental material which emboldens me to publish one more set of results in addition to what has already appeared[2]. The work was carried out while I was on the staff of the John Innes Horticultural Institution, Bayfordbury.

Golden Apple has medium-sized, round, bilocular, yellow-fleshed, yellow-skinned fruits on simple inflorescences. Oxheart has very large, inverted pear-shaped, multilocular, red-fleshed, white-skinned fruits on branched inflorescences.

Felföldy describes his technique as follows: "The upper parts [of the tomato plants] were interchanged".

* British Empire Cancer Campaign Research Fellow.

Only the simplest method of grafting was used: "the leaves were not removed either from parent, stock or scion". The age of the plants at grafting is not stated; but it is implied that stock and scion were of the same age. His results are presented in simplified form, with some interpretation, in Table 1.

Table 1

| Seed from scions of Oxheart/Golden Apple grafts | | | Seed from scions of Golden Apple/Oxheart grafts | | |
|---|---|---|---|---|---|
| *O* | 18 | | *G*, extra vigorous | 32 | |
| *O*, with non-pointed fruits | 12 | — | *G*, with some fruits 4-locular | 2 | — |
| | | 30 | | | 34 |
| Possible sexual $F_1$ | | 1 | | | |
| *G*, but with red-fleshed fruits, sometimes multilocular. Foliage intermediate | | 5 | *O*, non-pointed with flesh sometimes orange and skin yellow | | 6 |
| Total | | 36 | Total | | 40 |

*G* = Golden Apple or type; *O* = Oxheart or type

In my repetition, the first grafts were made with month-old plants. A wedge-shaped piece of stem from the scion was inserted in a slot cut in the main stem of the stock. The larger leaves were removed from the scion, and, in shaping the wedge, the first inflorescence was cut away. A lateral was allowed to grow on the stock in place of the main shoot. It was reasoned that this would maintain the vitality of the stock, without which its ability to influence the scion might be impaired. Three weeks from grafting, the scions of some grafts were defoliated and kept thus for the remainder of their growth. This would be expected to increase the effect of stock on scion.

A second series of grafts was made, of very young seedlings (twelve days from sowing) on to mature plants (two months old), with the wedge of the scion actually below the cotyledons. These scions were kept defoliated from the very first. Naturally enough, they grew very little and produced few fruits with few seeds (none at all in the Oxheart scions). All grafts were grown continuously in a heated glasshouse.

Thus, while some grafts were in all material respects the same as Felföldy's, the rest were modified in ways which should increase the physiological dependence of scion on stock and thus, according to Michurinist principles, increase the yield of graft hybrids.

In my own material, as in Felföldy's, apart from an increased vigour of the scions in grafts of Golden Apple on Oxheart, there was no indication of interaction between the grafts in the first season.

Table 2

| | Age of plants at grafting | Defoliation | Truss No. | Seed from Golden Apple | Seed from Oxheart |
|---|---|---|---|---|---|
| Control | — | — | — | 200 | (missing) |
| Stock | Stock and scion one month old | None | (on lateral stem) | 184 | 162 |
| Scion | " | " | 1 | 79 | |
| | | | 2 | 125 | 199 |
| | | | | 204 | |
| | " | Of scion, from 3 weeks after graftings | 1 | 97 | |
| | | | 2(base) | 26 | 125 |
| | | | (tip) | 52 | |
| | | | | 175 | |
| | Stock 2 months, scion 12 days | Of scion, from grafting | 2 | 10 | |
| | | | 3 | 13 | |
| | | | | 23 | |
| | Totals from scions | | | 402 | 324 |
| | Totals from grafts | | | 586 | 486 |
| | No. of graft hybrids | | | nil | nil |

Seed was saved from both stock and scion, each fruit being kept separate and its truss recorded. Each test family was from a single fruit. Details of the origin of each family are given in Table 2.

Mature plants were produced from 586 seeds of Golden Apple grafted to Oxheart and from 486 seeds of Oxheart grafted to Golden Apple. Not one of these showed evidence of vegetative hybridization for unambiguous characters such as fruit colour, skin colour, fruit shape, and number of loculi. One plant from Golden Apple had small seedless fruits and narrow leaves. It showed no signs of Oxheart influence. Its aberrance was evidently due to some other cause, say, aneuploidy. Golden Apple fruits are extremely uniform and any Oxheart influence should have been readily recognized. In Oxheart progeny, on the other hand, the recognition of hybrids would not be so easy, as the fruits are always very variable in size and shape, though constant in skin and flesh colour of the ripe fruits. It was, however, always possible to find at least one typically shaped fruit on a plant.

There was one complication. One of twelve plants from the first sowing of Oxheart seed as supplied to me proved to be an $F_1$ hybrid the parents of which had evidently been the two varieties under study. If such a plant had been inadvertently used as scion in a graft-hybrid experiment, some of Felföldy's results could be explained. Though I found no cases of spontaneous cross-fertilization in my material, Hungarian conditions are evidently more conducive to it.

Felföldy claimed twenty-two out of forty seedlings from Oxheart on to Golden Apple as hybrids. Of these, however, twelve can be explained as typical environmentally produced variants, and one appears to be an $F_1$ hybrid, leaving five which cannot be explained so easily. Similarly, in the Golden Apple – Oxheart series there are six variants out of forty, which, if we do not accept as genuine vegetable hybrids, are difficult to account for. Nevertheless, this hard core of fifteen 'hybrids' out of eighty is in such contrast to 0 out of 1,072 in my own experiment, which on the face of it provided more favourable conditions for vegetative hybridization, that one cannot take it seriously. [Feb. 10

Since the above account was written, Dr. Felföldy has kindly sent me the results of raising a further seed generation from the variants obtained in his grafting experiments.

*Oxheart/Golden Apple grafts* (see Table 1).

*O:* 40 plants raised, bred true as typical Oxheart.

*O, with non-pointed fruits:* 39 plants, bred true as a non-pointed form of Oxheart. My earlier conclusion that this would be non-heritable variation is thus wrong. Either the variant is a result of grafting or the original Oxheart was polymorphic, consisting of two true-breeding lines, one pointed, the other flat. This is not unusual in commercial strains of inbreeding crops[4].

*Possible sexual $F_1$:* This did indeed produce a typical $F_2$ segregation (39 plants), which agreed closely with the progeny of the chance $F_1$ hybrid which appeared in my own experiment. There was Mendelian segregation for flesh and skin colour and a more indeterminate (probably polygenic) variation for fruit shape and loculus number.

The progeny of the last category (29 plants, of which 27 produced ripe fruits) segregated for flesh colour (21 red; 6 yellow) and skin colour (21 yellow;

6 colourless) but bred true for the other fruit characters. It must have been a hybrid of some kind, but if a sexual one, it was not between Oxheart and Golden Apple.

*Golden Apple/Oxheart grafts.*

*G, extra vigorous:* 40 plants; and

*G, with some fruits 4-locular:* 28 plants. Both these classes produced only typical Golden Apple plants, vindicating my characterization of the latter group as non-heritable variants.

*O, non-pointed:* this was another class which I was unable to explain. It must have been a hybrid of some kind. Eight plants were raised, of which only five plants produced ripe fruits, but there was segregation for skin colour.

[1] McLaren, Anne, and Michie, D., *Nature*, **174**, 390 (1954).
[2] Felföldy, L., *Acta Biol. Acad. Sci. Hung.*, **2**, 3 (1951).
[3] Sachs, L., *Nature*, **167**, 282 (1951). Wilson, K. S., and Withner, C. L., *Amer. J. Bot.*, **33**, 796 (1946).
[4] Bateman, A. J., *Ann. App. Biol.*, **39**, 129 (1952).

# A SIMPLE AND RAPID ASSAY OF OXIDATIVE PHOSPHORYLATION

By Dr. BRITTON CHANCE and Dr. G. R. WILLIAMS

Johnson Research Foundation, University of Pennsylvania, Philadelphia

In seeking a method for the assay of oxidative phosphorylation that could be used under the same conditions as the spectrophotometric methods[1], we have developed a simple and rapid assay method that may be of general interest. By taking advantage of the fact that carefully prepared mitochondrial preparations are 'tightly coupled'—that is, respire only slowly in the absence of phosphate acceptor[2]—we find it is possible to measure accurately the amount of rapid respiration caused by the addition of a known concentration of adenosine diphosphate.

Respiration is most conveniently measured with a modified form of a vibrating platinum microelectrode[3], which has a more rapid response than the stationary electrode[4] and is more convenient than the rotating electrode[5]. The particular form of electrode developed for these purposes is suitable for insertion into a cuvette for the simultaneous measurement of spectroscopic, respiratory and phosphorylative effects[1]. An 8-mil. glass-coated open type of electrode is attached to the reed of a Brown Instrument Company's converter that vibrates the electrode at 60 c./s. and also forms a part of the electronic amplifying circuit (Chance, unpublished work). The electrode is polarized at $-0{\cdot}6$ V.

*Accuracy and controls.* The linearity of the electrode has been tested by inserting it into solution equilibrated with various oxygen concentrations obtained from a gas mixer[6], or by measuring its response to the zero-order respiration of a suspension of yeast cells. The non-linearity is less than 10 per cent. The calibration with a known oxygen concentration is explained in conjunction with Fig. 1.

Since the experiments with mitochondria are most conveniently carried out in an open cuvette in order to permit addition of reagents, there can be mixing of the air-saturated interfacial layer with the contents of the cuvette. This mixing-rate is negligible compared with the respiration-rate of the suspensions when adenosine diphosphate is present; but in its absence, rates of respiration less than $0{\cdot}1$ $\mu M$ oxygen/sec. may be in error at half atmospheric concentrations of oxygen.

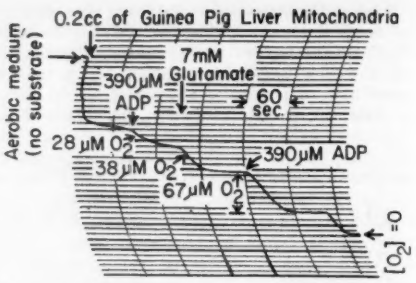


Fig. 1. Effect of additions of adenosine diphosphate upon the respiration-rate of guinea pig liver mitochondria as recorded by the vibrating platinum microelectrode. The mitochondria are diluted in a medium containing all factors except substrate and phosphate. The addition of the various reagents is indicated on the graph (Exp. 372)

The solubility of air in the reaction medium is computed according to ref. 7. The concentration of adenosine diphosphate is assayed spectrophotometrically[8], and the samples used (Sigma chromatographed) contained more than 95 per cent adenosine diphosphate, the remainder being largely adenosine monophosphate.

The mitochondria were prepared according to a modification of the method of Schneider[9] similar to that used by Lardy and Wellman[2]. Glass-distilled water was used throughout. The reaction medium contains $0{\cdot}038$ $M$ $Na^+$, $0{\cdot}087$ $M$ $K^+$, $0{\cdot}006$ $M$ $Mg^{++}$, $0{\cdot}096$ $M$ $Cl^-$, $0{\cdot}013$ $M$ $HPO_4^{--}$, $0{\cdot}003$ $M$ $H_2PO_4^-$, $0{\cdot}012$ $M$ $F^-$.

Fig. 1 illustrates the important aspects of this method. The brief portion of the trace that begins in the upper left portion of the figure is obtained by inserting the electrode into air-saturated reaction medium. When the mitochondrial suspension ($0{\cdot}2$ c.c.) is added to the reaction medium, the electrode current shows an abrupt decrease (downward deflexion) caused by the dilution of the oxygen in the reaction medium by the anaerobic mitochondria and by a diminished sensitivity of the electrode in the presence of the mitochondrial proteins[4]. The remaining oxygen concentration is readily computed from the dilution factor ($0{\cdot}8$ for Fig. 1), and this value serves to calibrate the electrode sensitivity, the zero point being given by anaerobiosis.

The mitochondrial respiration is rather slow because the endogenous adenosine diphosphate-level is very low, but is considerably increased by the addition of adenosine diphosphate as illustrated by the increased slope of the trace. This increased respiration is brief, and in less than a minute the respiration has very nearly ceased. In this case the adenosine diphosphate is still present; but the endogenous substrate has been exhausted. Now addition of 7 m$M$ glutamate causes a very rapid respiration which halts abruptly when the original addition of adenosine diphosphate becomes exhausted. Since ample substrate is now present, a second addition of adenosine diphosphate initiates respiration that continues until the adenosine diphosphate is used up. A third addition of adenosine diphosphate restarts the rapid respiration that is stopped this time by exhaustion of the dissolved oxygen in the reaction mixture and the system becomes anaerobic.

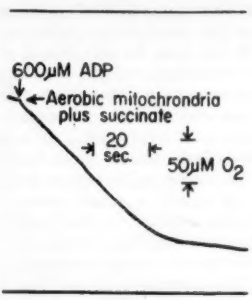


Fig. 2. Kinetics of initiation and cessation of rapid respiration. Rat liver mitochondria with succinate as the substrate (Exp. 332b)

Different portions of this record illustrate various aspects of the method. Taking up the additions of adenosine diphosphate in reverse order, the third one illustrates the calibration of the electrode sensitivity between the limits of zero oxygen and that of the reaction mixture diluted by the mitochondria. The second addition of adenosine diphosphate causes a rapid oxygen uptake of 67 $\mu M$ for the utilization of 390 $\mu M$ adenosine diphosphate. The ratio of adenosine diphosphate to atoms of oxygen is 2·9. A control on the destruction of adenosine diphosphate in the absence of respiration is provided by the first addition of the diphosphate. In this case the total time for the utilization of adenosine diphosphate is 70 sec. as compared with 40 sec. in the case of the second addition. Yet the oxygen utilized is very nearly the same, 66 and 67 $\mu M$ respectively. Thus just as much oxygen must be utilized to exhaust the adenosine diphosphate in the longer period as in the shorter period, and the rate of utilization of adenosine diphosphate in processes that do not lead to respiration is negligible.

The first addition of adenosine diphosphate also illustrates that the mitochondria contain a definite amount of readily available endogenous substrate, in this case equivalent to 28 $\mu M$ oxygen. The nature of the endogenous substrate is not known; but malonate is a potent inhibitor of this respiration. With rat liver mitochondria, the value of the ratio of adenosine diphosphate to atoms of oxygen for the endogenous substrate is less than that for β-hydroxybutyrate, and consequently its initial values are less than the final values obtained after the endogenous substrate has been oxidized.

The initiation and cessation of respiration upon addition of adenosine diphosphate is recorded on a faster time scale as shown by Fig. 2, in which succinate is used as the substrate for a rat-liver preparation. Rapid respiration is initiated in the mixing time (~1 sec.), much more rapidly than can be shown by the manometric method[10].

The cessation of rapid respiration is also abrupt, and by plotting the rate of respiration as a function of the change of oxygen concentration, we find that the respiration falls to half the rapid value with an oxygen utilization of only 7·5 $\mu M$. For a value of 2·0 for the ratio adenosine diphosphate to atoms of oxygen for succinate, we find that the 'Michaelis constant' for the deceleration of respiration by exhaustion of adenosine diphosphate is $7{\cdot}5 \times 2 \times 2 = 30$ $\mu M$ diphosphate. If this experiment is repeated by adding small amounts of adenosine diphosphate and measuring the respiration-rate, a value of 20 $\mu M$ diphosphate is obtained for a guinea pig liver preparation. These values are probably more representative than those of Slater and Holton[10], where a high endogenous concentration of adenosine diphosphate was present in the 'loosely coupled' heart sarcosomes.

The rapidity with which respiration is initiated and the high affinity for adenosine diphosphate are sufficient to account for the available experimental data on intact muscle, for example, Millikan's finding that 10–25 per cent of the oxymyoglobin reservoir of cat's soleus muscle was expended 1 sec. after a tetanic contraction[11]. It is also apparent that the affinity of the oxidative phosphorylation system for adenosine diphosphate is sufficient to respond to a fraction of the concentration of the diphosphate that is believed to be released by a single muscle twitch. The 'Michaelis affinity' for adenosine diphosphate is about 25 $\mu M$, whereas the amount thought to be released per twitch is equivalent to 300–500 $\mu M$ [12]; thus only about 6 per cent of the adenosine diphosphate released per twitch should be needed for half-maximal stimulation of respiration. This conclusion is supported by our experimental observations of a change in the steady-state level of intracellular pyridine nucleotide following a single twitch of aerobic frog sartorius muscle at 0° [13].

Since we have shown that a negligible amount of adenosine diphosphate is utilized by these preparations without causing respiration, and that the affinity of the system for the diphosphate is very high, we may conclude that there is an incorporation of inorganic phosphate equal to the amount of added adenosine diphosphate in the interval of rapid respiration (see Figs. 1 and 2). A relatively crude analysis of inorganic phosphate uptake[14] at the end of this interval gave 1·6 and 1·5 m$M$ phosphate disappearance compared with 1·7 m$M$ adenosine diphosphate added. Thus it is reasonable to regard our adenosine diphosphate/oxygen ratios as phosphorus/oxygen ratios without correction. While we do not claim to settle finally the controversial question of phosphorus/oxygen values by these results[15], we do believe that the simplicity, rapidity and directness of this method have much to recommend it. For a typical guinea pig liver preparation we find the phosphorus/oxygen (atoms) values to be 3·1 with glutamate as a substrate. An average value of 3·1 is obtained from four determinations with rat liver mitochondria using β-hydroxybutyrate as a substrate. Ten determinations of the relative phosphorus/oxygen values for succinate and β-hydroxybutyrate gave the factor 0·68 as a result. Full details of this work will be published elsewhere.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## A New Interpretation of the Mechanics of Pulvinar Movement

Knowledge of the mechanics of pulvinar movement is based mainly on the work of Dutrochet[1], Pfeffer[2] and others conducted in the nineteenth century. They showed that if the upper half of the primary pulvinus was removed from the leaf of *Mimosa pudica* then leaf movement continued, although on a reduced scale. It was deduced from this that the lower half of the pulvinus is principally concerned with the movement, which was then accounted for in terms of loss of turgor followed by recovery. This early explanation of pulvinar mechanics is still widely accepted by workers in this field[3], and has recently been used in drawing comparisons between the movement of guard cells and pulvini[4]. The results are briefly reported here of studies on leaf movement exhibited by *Samanea saman* Merrill and *Mimosa pudica*. In our view they cast doubt upon the validity of this explanation.

The above experiment was repeated, in a modified form, upon the secondary pulvinus of the leaf of *Samanea*, which has the same nyctinastic response as the primary pulvinus of *Mimosa*, that is, curving downwards in the evening towards the 'closed' position, and upwards in the early morning towards the 'open' position. During the day, this pulvinus supports the weight of the leaflets, to which it is attached by the rachis. The latter acts as a lever, so that a pressure is exerted upon the lower half of the pulvinus and a pull on the upper half. In the experiment described here the pulvinus was relieved of these forces. This was done by orientating the leaf in such a way that the pinna moved in the horizontal plane, instead of the vertical, and then by suspending the end of the pinna from a freely swinging arm with a fine thread.

Three leaves were set up as above. The first served as a control, and it showed the normal nyctinastic movement, although now in the horizontal plane. At midday the upper half of the pulvinus was removed from the second leaf, and the lower half from the third. Afterwards the second pulvinus curved a little farther in the 'open' direction, where it remained permanently, the nyctinastic movement disappearing completely. The pulvinus of the third leaf commenced to 'close' immediately after the removal of the lower half. When it had attained the fully 'closed' position, no further nyctinastic movement was shown by it also. In each case the remaining half of the pulvinus stayed fully turgid and healthy in appearance throughout the experiment. Identical results were obtained when this experiment was repeated using the primary pulvinus of *Mimosa*. Here the seismonic response also disappeared. This confirmed the work of Bert[5], who reported that movement in *Mimosa* disappeared when the petiole was placed on its side and the upper half of the pulvinus removed. Thus neither the upper nor the lower half of the pulvinus alone is able to bring about leaf movement. This suggests that movement in the complete pulvinus is due to the upper and lower halves alternately expanding and compressing the opposite half.

It was confirmed that a reduced movement occurs in the normally orientated leaves of *Mimosa* and *Samanea* when the upper half of the primary pulvinus of *Mimosa*, or the secondary pulvinus of *Samanea*, is removed. It can now be attributed to the leverage effect already described, which acts upon the lower half of the pulvinus as a compressing force, inducing the cells to lose water, with subsequent contraction in volume. Hence a nyctinastic or seismonic movement can take place under these conditions. Confirmation of this explanation comes from experiments on *Samanea*, in which a small, constant, upwardly directed force was applied continuously to a pulvinus from which the lower half had been removed. Reduced nyctinastic movement then occurred, although such movement is not normally shown by the upper half alone. The occurrence of a nyctinastic rhythm in circumstances where one remaining half of the pulvinus is subject to a constant compressing force suggests that the ability of the cells to withstand compression varies diurnally. In the complete pulvinus it is least among cells of the lower half at the end of the day. Therefore at this time the force exerted by the upper half, together with the leverage effect, is now sufficient to cause the cells of the lower half to lose water. The tissue is then compressed into a smaller volume and, as a result, the pulvinus curves downwards and the leaf 'closes'. In the early morning the reverse occurs, the cells of the lower half regaining their turgor and exerting a compressing force on the cells of the upper half, which in their turn are now least able to withstand compression. They lose water and are compressed so that the pulvinus bends the leaf back into the 'open' or day position.

It is therefore concluded that pulvinar movement is caused by a force resulting from increase in turgor in one half of the pulvinus acting on cells in the other half, which are in a receptive state for compression. In the case of 'closure', this force may be supplemented by the effect of gravity.

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## Rhythmic Flight Activity of Certain East African Trichoptera

While studying the cyclical emergence of aquatic insects from Lake Victoria, observations were made on their flight activity throughout the night. Similar investigations[1–4] conducted in temperate regions have been chiefly concerned with terrestrial insects.

In the present study, the number of insects caught in a Robinson-type insect trap[5] fitted with a 125-W. mercury vapour bulb was taken as a measure of flight activity. A receptacle containing alcohol placed inside the mouth of the trap ensured that all incoming insects were killed immediately. This container was changed at 10-min. intervals during 18.00–07.00 hr. East African Standard Time. The trap was situated about 300 metres from the lake-shore on raised ground. Plecoptera, Ephemeroptera, Hemiptera, Trichoptera, Coleoptera and Chironomidae were represented in the

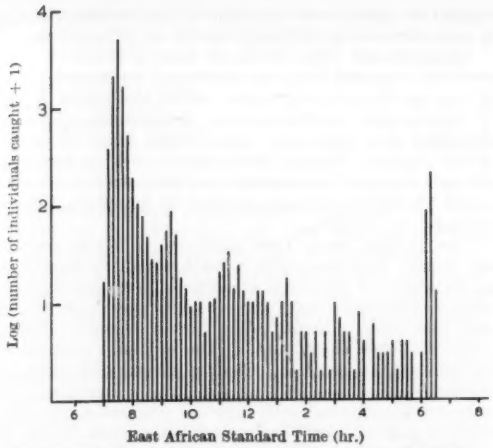


Fig. 1. Flight activity of *Cheumatopsyche* sp. nov. (Kimmins, in the press) (Hydropsychidae) throughout the night of January 5–6, 1955

catch; only certain species of Trichoptera were identified, sexed and counted. This involved inspection of more than 40,000 individuals collected on five nights in December 1954 and January 1955.

In the Ephemeroptera, Trichoptera and Chironomidae (considered as groups) flight activity was bimodal, the greatest numbers being caught shortly after sunset and again just before sunrise. A similar rhythm has been noted previously among Chironomidae in temperate regions[4]. In these instances it is not known to what extent this pattern of activity is brought about by the same species flying twice during the night or by different species, some flying only at dusk and others only at dawn.

Among the Trichoptera identified, we found that seven species showed a clear bimodal flight activity (Fig. 1). In six of these species the main flight occurred at dusk, after which the numbers declined gradually throughout the rest of the night. The dawn flight began and finished abruptly, and during this time activity in a single 10-min. period could sometimes exceed that observed at dusk the same night. In the seventh species the main flight occurred at dawn.

The significance of the two periods of activity in the life-histories of these insects is not clear. It seems likely that greater sexual activity occurs at dusk: copulation and oviposition have been observed more frequently at this time, and a smaller proportion of females occurs at dawn. The degree of synchronization observed may perhaps be an indication of a short reproductive life. In this connexion it may be remarked that animals in which activity is stimulated by crepuscular light intensities may be expected to show closer synchronization in tropical than in temperate regions.

The immediate practical outcome of these findings is that studies on the distribution, abundance and cyclical emergence of Trichoptera can now be made with far greater economy of effort since, by sampling during the dusk and dawn flights only, a collection can be obtained which not only includes a majority of the species flying during the night, but also a representative sample of the more abundant ones. This will substantially reduce the labour of sorting and identifying the material—a procedure which at present forms the principal barrier to progress in studies of this type.

This work was carried out at the East African Fisheries Research Organization, Jinja, and a full account is shortly to be published elsewhere.

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## Shell-structure of the Brachiopod *Lacazella mediterraneum* (Risso)

THE continued use of Beecher's ordinal classification[1] of the Brachiopoda despite its inconsistencies[2] is mainly due to his fascinating interpretation of Kovalevskii's observations[3] on the development of the recent thecideid *Lacazella*. Beecher concluded that the pseudodeltidium was secreted not by the mantle fold of the thoracic segment but by the caudal segment, and that only later was it ankylosed to the pedicle valve. Further, the pseudodeltidium appeared to be identical with a similar structure invariably found in the extinct strophomenoids (the central group of his order *Protremata*), a comparison that led him to regard the thecideids as derivatives of that stock. In other articulate brachiopods (the *Telotremata* of Beecher), the delthyrium is usually constricted by deltidial plates, sometimes fused into a single unit, which are undoubtedly secreted by extensions of the mantle. Thus on the assumption that the pseudodeltidium was a 'third shell', Beecher was able to draw a fundamental distinction between the two groups. Substance was added to the supposed alien nature of the pseudodeltidium by his belief that in protrematous brachiopods the pseudodeltidium was always impunctate, even when the valves were punctate as in the strophomenoids.

The links in this chain of reasoning began to break when Kozlowski[4] pointed out that the strophomenoids are not punctate in the terebratuloid manner. What had previously passed for punctæ were in fact calcite spicules embedded in the inner fibrous layer and projecting from it as a series of tubercles. These cannot be homologized with the cæcal extensions of the mantle which form the punctæ and penetrate the outer lamellar layer of the shell as well as the inner fibrous one. The structure of the strophomenoid pseudodeltidium, therefore, does not differ from the rest of the shell; it appears impunctate because it is covered by the lamellar layer, which is never penetrated by spicules. A further modification of Beecher's views became necessary when Elliott[5] showed that the valves of the thecideids are truly punctate. But the internal shell surface is also tuberculate in a manner reminiscent of the strophomenoids, and accepting the possibility that punctation had arisen independently in the thecideids, *Lacazella* and its Mesozoic ancestors could still have been derived from the strophomenoids.

Dried specimens of *Lacazella* (*BM.ZB*141) show that the entire shell, including the pseudodeltidium, is punctate in the terebratuloid manner even to the

possession, by the cæcæ, of setiferous brushes penetrating the outermost lamellar layer. From the disposition of the periostracum and the dried mantle relative to the hinge line, it also appears that the pseudodeltidium is deposited by an extension of the ventral mantle, the outer lobe of which fuses with the outer lobe of the dorsal mantle to produce a single thickened periostracal sheet lying across the hinge line as in terebratuloids. There is therefore no reason for supposing that the pseudodeltidium of adult *Lacazella* at least originates differently from the rest of the shell.

Moreover, the resemblance between the tubercles of *Lacazella* and the spicular surface of the strophomenoids is only superficial. In strophomenoids, as in most brachiopods, the calcite fibres of the inner shell layer are disposed obliquely to the lamellar layer, changing direction only in narrow zones peripheral to the embedded spicules. In *Lacazella* the fibres are inclined at high angles to the lamellar layer, and are segregated into closely spaced bundles in such a way that the fibres of each bundle splay out slightly, to lie more or less normal to the irregularly tuberculate inner surface of the shell. Consequently, the bundles in cross-section appear to be made up of a core of vertically disposed fibres surrounded by a zone of radiating ones. It is these bundles which have previously passed as pseudopunctæ; but they do not possess a non-fibrous core of any kind, and are unrelated to the strophomenoid spicules.

Unusual as this shell-structure is, it is not unique. The tubercles of the terebratuloid *Megerlina lamarkiana* (Davidson) appear to be identical in origin with those of *Lacazella*; although since the tubercles of *Megerlina* are widely spaced, the fibres between them revert to the more usual oblique angle of disposition. Indeed, allowing for their wide scatter and taking into account punctation, the similarity between the shell-structure of the two stocks is striking.

The above observations emphasize the urgent need of a re-investigation of the development of *Lacazella*. Meanwhile, serious consideration must be given to the possibility that the thecideids were derived neotenously, not from the strophomenoids, but from the schizolophous young of some Triassic terebratuloid or punctate spiriferoid.

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## Shell-structure of Thecidean Brachiopods

In thecidean brachiopods, which range from the Rhaetic to the present day, the shell-structure is less definite, and shows more variation, than in many other brachiopod sub-orders. Investigations I have carried out of this point[1], as part of work undertaken for a "Treatise on Invertebrate Paleontology", resulted in the conclusion that the structure was initially obscurely pseudopunctate, becoming densely punctate when a certain degree of structural organization was attained. This punctation never shows the regular *en quinquonce* pattern of the terebratuloids: it was attained in different stocks at different dates.

These results were obtained from a study of thin sections prepared from specimens of the type-species of various thecidean genera. Since the major types of brachiopod shell-structure, impunctate, pseudopunctate and punctate, characterize large divisions of the phylum, further investigation was undertaken of available material and sections prepared of twenty-seven thecidean species ranging in age from Lower Jurassic to Recent.

The results show that eighteen of these species are clearly punctate, and a further six are identified as "fibrous; ? scattered punctae". Two are fibrous, without punctae; only one is clearly pseudopunctate, and this genus (*Davidsonella*, Lower Jurassic) differs from all other thecideans in the extreme elongation of the brachial cavities. Clear punctation appears in certain species as early as the Lower Jurassic, and without association with brachial complexity as previously stated. This early punctation was noted by Deslongchamps[2] and inadvertently overlooked by me.

In view of the very small size of those brachiopods and the varied preservation of the material examined, the evidence summarized above is now interpreted as indicating that the thecidean brachiopods are punctate.

This punctation is very irregular in development throughout members of the sub-order, and does not show the regular patterning of terebratuloid punctation. Investigation of the physiological significance of punctae in living brachiopods might throw light on this condition.

*Davidsonella*, exceptional in shell-structure and brachial form, may be of separate evolutionary origin, although conveniently grouped at present with the others.

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## Feeding of Barnacles

At the start of an investigation into the rate of feeding of the different species of intertidal barnacles, I was surprised to find that there was very little published information on the methods employed for the capture of food or on the organisms eaten by these ubiquitous animals. Darwin[1] noted the presence of Infusoria and Confervae in the gut as well as the remains of quite large Crustacea, and the newly settled spat have been reared on pure cultures of unicellular Algae[2]; but Gruvel[3] and Batham[4] have described only a macrophagous method of feeding, whereby animals that touch the extended third to sixth cirri are immediately drawn into the shell by the cirri and masticated by the mouth-parts. It is therefore interesting to report that some experiments in progress show that the adult barnacle can feed on a very wide range of organisms, from a size of 1 mm. down to 2μ.

For example, a specimen of *Balanus perforatus* captured and ingested the following organisms, as demonstrated both by their removal from the water around the barnacle and their appearance in the fæcal pellets:

| Organism | Rate of feeding, as ml. water filtered per hr. | Time to 50 per cent clearance |
|---|---|---|
| Nauplii of *Artemia salina*, 0·75–1·0 mm. length | 4–15 | 1½ hr. |
| *Peridinium* sp., 30μ diam. | 2–9 | 1½ hr. |
| *Gymnodinium* sp., 10μ diam. | 2–3 | 5 hr. |
| Rod-shaped bacteria, 2μ length | by examination of fæcal pellets only | |

As the minimum width of the spaces in the 'net' formed by the third to sixth cirri and the setæ on them was at the least 33μ in this specimen, it is obvious that the cirri themselves could not have captured the Algae or Bacteria. Direct observation showed that the rhythmic beating of the cirri causes a current of water to pass over the mouth parts and the first and second cirri, which generally remain within the mantle cavity. These appendages, and especially the first and second cirri, bear groups of fine setæ, of the order of 1μ wide and spaced only about 1μ apart; this is presumably the filter that captures the small organisms.

It is hoped to give details of the filtration mechanism in a later publication; meanwhile it can be suggested that the wide range of food capable of being eaten by barnacles in part explains their great success on the shore and their ability to live in such dense communities.

I am indebted to Dr. M. Parke and Dr. J. A. C. Nicol for help and advice in this investigation.

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March 4.

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## Chromosome Numbers in the Rutaceae

Original chromosome counts for three members of the subfamily Rutoideae of the family Rutaceae are given as follows. *Correa backhousiana* has $n = 16$, in agreement with the counts for three other species of *Correa* found by Smith-White[1]. *Evodia danielli* has $n = 40$, this count differing from that found by Bowden[2], who gives $n = 36$ for material grown on the Blandy Experimental Farm, University of Virginia. My material, originally obtained from North China, is now growing in the Royal Botanic Gardens, Kew. Its chromosome number suggests aneuploidy. It is interesting to note the apparent existence of chromosome races within the species *Evodia danielli*. *Choisya ternata* has $n = 27$—a first count for the genus.

*Choisya ternata* shows slightly irregular meiosis, the irregularities being manifested by a few lagging chromosomes at anaphase. When collected even at the most favourable growing period, the anthers exhibited a considerable percentage of shrivelled, empty or otherwise defective pollen. This may be indicative of a hybrid nature in this species.

Illustrations of the meiotic stages from which counts were obtained accompany this communication.

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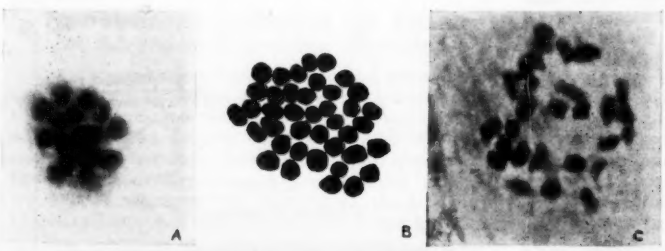


*A*, *Correa backhousiana*, first meiotic metaphase, pollen mother cell, $n = 16$ (× *c.* 1,270); *B*, *Evodia danielli*, first meiotic metaphase, pollen mother cell, $n = 40$ (× *c.* 1,270) (drawing); *C*, *Choisya ternata*, first meiotic metaphase, pollen mother cell, $n = 27$ (× *c.* 1,270)

## Properties, Function and Origin of the Alveolar Lining Layer

In acute lung œdema in the rabbit, fluid and foam are found in the trachea. This foam has an altogether peculiar property, in that it is unaffected by silicone anti-foams; these rapidly destroy the foams produced by shaking œdema fluid or blood serum with air. Equally stable foam is found in the bronchi of an animal the respiratory movements of which have been paralysed and into the trachea of which a mixture of oxygen and ammonia gas has been insufflated for one or two hours; similar foams are obtained from healthy lung by cutting and squeezing under water, or after introduction of saline into the trachea. The stability of such foams is due to an insoluble surface layer on the bubbles; this layer can be attacked by pancreatin or by trypsin.

Œdema foam is thus not produced by agitation of the œdema fluid with air during respiration; it can only have been formed by air originally contained in the fine air spaces of the lung being broken up into bubbles and afterwards expelled into the bronchi and trachea. The lining layer of the bubbles cannot have come from the œdema fluid, and must therefore have formed the original lining layer of the fine air spaces. By drying and weighing samples of the foam of known bubble-size distribution, the thickness of the layer (assuming density 1·3) has been found to be about 50 A.

In air-saturated water, bubbles (say 40μ in diameter) from foam from the lung usually remain unchanged in size for long periods (60 min.), whereas similar bubbles from serum and other foams, owing to their internal excess pressure, dissolve and disappear within a few minutes. The surface tension of the lung bubbles is therefore zero; or, to put this another way, the surface pressure of the layer is equal to the surface tension of the underlying liquid.

Published calculations[1] on the pressure balance between the lung capillaries and the alveoli have disregarded the surface tension at the sharply curved, and probably moist, alveolar wall. If the surface tension were that of an ordinary liquid,

enough suction would be exerted to fill the alveoli with a transudate from the capillaries. Means for keeping the surface tension low must therefore be part of the design of the lung. It is thus evident that the alveoli are lined with an insoluble protein layer which can abolish the tension of the alveolar surface.

40-$\mu$ bubbles squeezed from a fragment of the artificially inflated lung of a mature fœtal rabbit (within a few seconds of inflation) and kept in air-saturated saline usually contract by about 30 per cent in diameter and then remain stable. The layer is therefore initially formed by rapid surface adsorption from a substance already present in the fœtal lung. It probably matures somewhat during the first few hours after birth. A layer is likewise rapidly formed when an adult lung which has been consolidated is re-expanded.

By none of the many methods tried have small bubbles stable in air-saturated saline been regularly produced from blood or from amniotic fluid. The layer is thus not formed from either of these liquids, or from a transudate from the blood. Such bubbles have been formed from nasal (but not, so far, from tracheal) mucus; they are easily formed from a solution of an extract of hog gastric mucosa ('gastric mucin'), and from this solution also a foam resistant to silicone anti-foams has been prepared. These findings suggest that a layer of some form of mucus[2], secreted in the depths of the lung, is the source of the insoluble alveolar lining layer.

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March 3.

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## A Micromethod for Determination of the Circulating Blood Volume in Chick Embryos

We have devised a method for estimating the circulating blood volume in avian embryos from somite stages up to hatching, that is, practically from the onset of circulation in the embryo. Earlier publications on the subject[1,2] are concerned with the second half of fœtal life only.

In order to determine the volume of circulating plasma in chick embryos 1 per cent Geigy blue solution (Evans's blue) was used. The dye was dissolved in Ringer solution. The pigment was slowly injected by means of a glass micropipette, the bevelled orifice of which measured 50–150 microns in diameter. Injection (under Greenough binocular) was carried out on the second day of incubation into the sinus terminalis close by the anterior vitelline vein, from the third day until the fifth into the vitelline veins, from the sixth up to the nineteenth day into the allantoic veins, and the twentieth day as well as the first postembryonic day into the internal jugular vein. The position of veins in embryonic membranes makes possible a controlled intravascular injection. From the fourteenth day onwards, the necessary preparation of perivascular connective tissue was performed.

The amount of dye in the micropipette was determined by calibration with mercury (to 0·01 mgm.) or weighed directly (to 0·1 mgm.); we use 1 mgm. per 1 microlitre. The micropipette was emptied into the vein and rinsed with redrawn blood within 30–60 sec. The dye circulated for 3 min. and in the next 30–60 sec. the blood sample was taken. From the very moment of injection of the dye to completion of the sample (5 min.), the tip of the pipette did not leave the vein. The correct amount of solution which did not cause any disturbance in the circulation of plasma was determined. On average, the following amounts of dye solution were injected: day 2, 0·07 mgm.; day 3, 1 mgm.; day 4, 1·3 mgm.; day 5, 2·4 mgm.; day 6, 3·5 mgm.; day 7, 4·4 mgm.; days 8 and 9, 6·5 mgm.; days 10–13, 10–15 mgm.; days 14–18, 15–20 mgm.; and from day 19 to the first postembryonic day, 20–30 mgm. This amount represented 1–2 per cent of the total blood volume in the embryonated egg. From day 14 onwards, a tiny drop of heparin anticoagulant was placed in the bulb of the micropipette in order to prevent coagulation of the blood sample. This method enabled us to determine the amount of circulating plasma in the individual embryos except for day 2, when it was necessary to use pooled samples (six embryos).

The greater part of the sample was centrifuged in a capillary tube, and the portion of the capillary containing the dyed plasma was cut off. 5–50 mgm. of plasma was mixed with 1 ml. (up to day 5 with 0·5 ml.) of distilled water. The sample was put into a microcuvette (optical length 10·0 mm., content 220 $\mu$lit.) and the extinction read on a Pulfrich stufenphotometer at the wave-length 610 m$\mu$. The

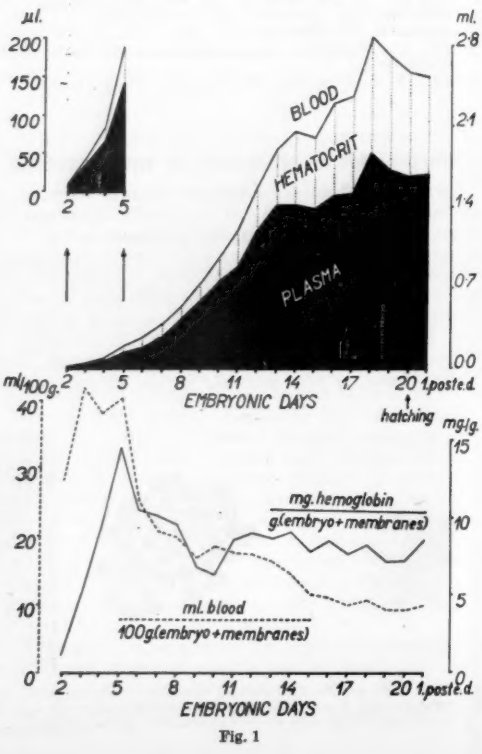


Fig. 1

amount of dye in the sample was determined from a calibration curve. The relationship between extinction and dye concentration is linear. The volume of circulating plasma was calculated from the dilution of the dye; the circulating blood volume from the plasma volume and the hæmatocrit.

Glass capillaries (diameter 0·1–1 mm., length 50 mm.) were filled with blood, one end sealed in fine-pointed flame, centrifuged for 15 min. and the hæmatocrit values measured in millimetres. These results were compared with values obtained by usual hæmatocrit tubes; the agreement was excellent[3]. In addition to these estimations, the same sample served for the determination of erythrocyte count and hæmoglobin. Geigy blue does not interfere with the determination of hæmoglobin. Up to day 7, it is essential to measure erythrocyte count, hæmatocrit and hæmoglobin separately, because Geigy blue causes sludging of primitive erythrocytes, whereas plasma circulation remains undisturbed.

Embryos were weighed; on the second and third days, respectively, the somite stage was estimated supravitally by neutral red (25 and 39 somites on average). For allantois and corrected yolk sac weights, Byerly's data[4] were used. The hæmatocrit values were not corrected; exsanguinated embryos were weighed. For this reason we are obliged to take the absolute as well as the relative data in Fig. 1 as maximal.

Each day of incubation, twelve embryos (White Leghorn) were used. The upper part of Fig. 1 shows the absolute values of plasma volume, hæmatocrit and blood volume, while in the lower part the relative amounts of the circulating blood and hæmoglobin are given. A full account of our experiments is to be published elsewhere[5]; meanwhile, we wish to emphasize the continuous decrease of the relative blood volume, in contrast to the fairly constant relative hæmoglobin from day 8 onwards. Our results also make it possible to calculate the basic characteristics of the average erythrocyte from the second day of incubation until hatching.

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## Neurohumoral Control of the Release of Adrenocorticotrophic Hormone

Since the stimuli which activate the anterior lobe of the pituitary gland to discharge adrenocorticotrophin (emotional stress, several drugs such as adrenaline, and so on) elicit a parallel release of antidiuretic hormone from the hypothalamus and from the neurohypophysis[1], we thought it worth while to investigate the possibility that posterior pituitary hormones may play a part in the regulation of the secretion of adrenocorticotrophic hormone from the adenohypophysis.

Since 1951, evidence was given that both the antidiuretic and the oxytocic hormones from posterior pituitary may produce a release of adrenocorticotrophic hormone from the anterior lobe. In normal dogs the intravenous injection of small amounts (1 U./kgm.) of both oxytocic and antidiuretic hormones activates the adenohypophysis to discharge adrenocorticotrophic hormone and thereafter produces eosinopœnia; doses even smaller than these (0·1 U./kgm.) produce a greater eosinopœnia when injected directly in the cerebrospinal fluid[2].

In normal rats the intravenous or intramuscular administration of small amounts of posterior pituitary hormones (0·3 U./rat) brings about a fall in adrenal ascorbic acid content, comparable in degree and in its time relationship to that produced by adrenocorticotrophic hormone[3]; ascorbic acid depletion is not due to contamination with hormone of the extracts used, since it does not occur in hypophysectomized rats[3].

Further proof that posterior pituitary hormones may activate the anterior lobe was furnished by experiments demonstrating that in normal dogs a marked and abrupt elevation in blood thyrotrophic hormone-level follows the injection of small amounts of posterior pituitary hormones (0·2 U./kgm.) into the cerebrospinal fluid[4].

Experiments now in progress show that posterior pituitary hormones may produce also a discharge of luteotrophin from the anterior pituitary.

The evidence given in the papers mentioned suggests that the hypothalamus may control pituitary adrenocorticotrophic hormone output by release of antidiuretic and/or oxytocic hormone(s), and that posterior pituitary hormones may be the unidentified 'neurohormone' reaching the adenohypophysis through the portal vessels, as suggested by Harris's experiments[5].

Our findings have been confirmed by several authors[6], and our hypothesis has been accepted and supported also by Mirsky *et al.*[7] and by McCann *et al.*[8]. Clear-cut evidence has been provided now by Rothballer[9] and by Barnett[10], who have shown that after exposure of rats to pain stimuli the neurosecretory material found in the hypothalamo-hypophysial system is depleted from the median eminence and from the infundibular process into the portal vessels, to reach the adenohypophysis.

Further support for our hypothesis is provided by the determination of adrenal cholesterol content in rats receiving posterior pituitary hormones.

Forty-eight male albino rats (100–150 gm.) were divided into three groups: the first received oxytocic hormone (0·3 U./rat 'Pitocin', Parke-Davis), the second antidiuretic hormone (0·3 U./rat 'Pitressin', Parke-Davis), the third 0·2 ml. of saline solution. The hormones were diluted to 0·2 ml. of saline solution and injected subcutaneously. Total adrenal cholesterol determinations were carried out by the method of Sperry and Webb[11].

The results obtained are summarized in Fig. 1. Antidiuretic hormone produces a significant fall of adrenal cholesterol; oxytocin decreases adrenal cholesterol, too, but this fall is not significant. When the same experiment was repeated on hypophysectomized rats, the results illustrated in Fig. 2 were obtained; there was no depletion of cholesterol in hypophysectomized rats after administration of either antidiuretic or oxytocic hormone. This demonstrates that cholesterol depletion after injection of posterior pituitary hormones is not due to contamination of the materials injected with adrenocorticotrophic hormone.

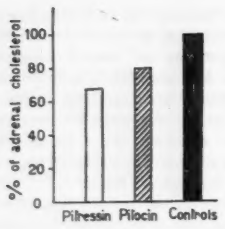


Fig. 1

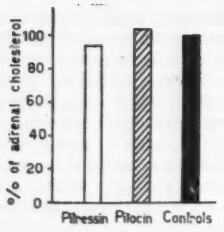


Fig. 2

Fig. 1. Effect of the subcutaneous injection of posterior pituitary hormones on adrenal cholesterol of normal rats

Fig. 2. Effect of the subcutaneous injection of posterior pituitary hormones on adrenal cholesterol of hypophysectomized rats

These results confirm that posterior pituitary hormones may activate the anterior lobe of the pituitary gland to discharge adrenocorticotrophic hormone and indicate that antidiuretic hormone of the posterior pituitary may be considered as a possible neurohumoral transmitting agent.

Experiments to be published, carried out on hypophysectomized rats bearing pituitary transplants in the anterior chamber of the eye, demonstrate that the action of posterior pituitary hormones on the adenohypophysis is direct and not mediated through nerve centres.

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## Simultaneous Evaluation of Circulating Eosinophils, Polymorphonuclears and Lymphocytes by Phase-contrast Microscopy

While counting blood eosinophils, it may be very useful to determine the corresponding number of the other white cells in the same preparation. This can be effected in a simple and reliable way, by using phase-contrast microscopy and a modified Zollikofer's solution[1], composed of 1 ml. yellow eosin (2 per cent aqueous solution, kept in a refrigerator), 3 ml. formalin (40 per cent, neutralized with calcium carbonate) and distilled water to make up 100 ml.

In order to count the eosinophils in dogs, rats and man, we used the following technique: the blood sample is drawn quickly into a micropipette, carefully adjusted to the mark, and, diluted to 1/20 in a precisely measured amount of the fluid described, contained in a small test-tube (rimless, approximately 7 mm. × 50 mm., commonly used in serological agglutination tests). As they occur almost instantly, fixation and staining need not be waited for; on the other hand, immediate counting is not essential, provided evaporation of the blood-fluid mixture is prevented.

After a few seconds of gentle shaking by hand, the mixture is run into a Fuchs–Rosenthal counting chamber (dimensions: height 0·2 mm.; counting surface, two rulings of 4 mm. × 4 mm., large squares of 1 mm. side, small squares of ¼ mm. side; four rulings were always counted for one evaluation), where the eosinophils appear bright red on a clear background, whereas the other unstained white blood cells are barely visible as 'ghosts'.

By switching over from bright-field to phase-contrast, and preferably from a lower to a higher magnification, in a suitably equipped microscope, those 'ghosts' become so clearly defined that distinguishing between polymorphonuclears and lymphocytes becomes readily possible. Also the blood platelets are well shown up; their degree of agglutination provides an index of the clotting tendency in the blood sample at the moment it was withdrawn, being minimal in the most quickly secured, and therefore the most reliable, specimens.

The enumeration of the white blood cells can be effected by counting a row of 16 small squares, multiplying the results by 100, and thus obtaining the number of leucocytes—polymorphonuclears and lymphocytes—per mm.³. To reduce counting variations, especially when the number of leucocytes is relatively low, two or more rows are checked.

As usual, and especially in this method, one has to wait long enough for the particles to settle down on the bottom of the counting chamber. To ascertain comparability of results, it is, of course, highly advisable to observe a standard routine for every step of the procedure and to avoid contamination with foreign particles.

Whenever an immediate count is not carried out, two precautions are of the utmost importance: (1) the small test-tubes must be kept closed, preferably with a rubber cork; (2) mechanical shaking for one to

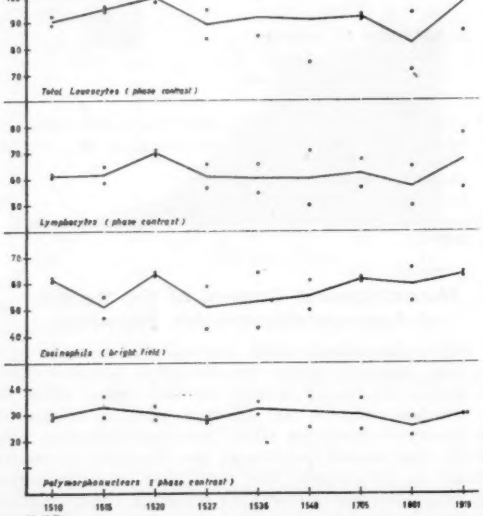


Fig. 1. 'Early' differential counts of white blood cells as a function of time (two counts per chamber. curve of means). Cardiac puncture at 15.03

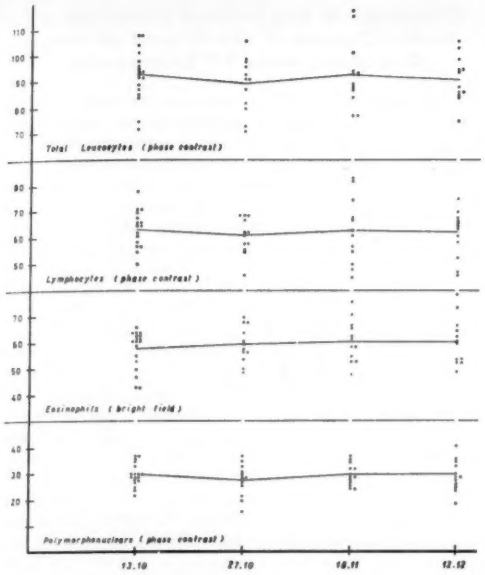


Fig. 2. 'Late' differential counts of white blood cells at two-weekly intervals

two minutes is necessary before running the fluid into the counting chamber. As will be proved elsewhere in more detail, not so much the evaporation itself but the agglutination of the cells and adhesion to the glass wall at the edge of the evaporating solution must be considered disturbing factors.

Repeated counts and statistical analysis of the results have demonstrated that the white blood cell counts obtained by this method agree with those found by classical procedures and, as is also the case for the eosinophils, show no significant differences in the same specimen stored for at least two months, and probably for even longer periods.

Studying the second point, we found, after several trials, the most adequate technique to be the following. A 20-ml. syringe was filled with modified Zollikofer's fluid and 1 ml. blood was then drawn into it by cardiac puncture of an ether-anæsthetized rat. To exclude very early changes in the cell numbers, the preparation was—after thorough shaking of the syringe and changing the needle—run directly into the counting chambers. Counting was started as soon as possible, and repeated at steadily increasing intervals up to four hours afterwards. Using the rank correlation method of Kendall[2], no significant trend was found for any cell type, as illustrated also by the curve in Fig. 1. The rest of the preparation was kept in small test-tubes, closed with rubber corks, and countings were repeated about every two weeks. Also in this case there were no significant differences in the results (Fig. 2).

Although a comparative study of other methods is proceeding, the most important advantages of our method can already be summarized here: (1) the absolute and relative counts of the different white blood cells are obtained in one and the same preparation; (2) the cells are extremely well preserved qualitatively and quantitatively for longer periods than has been claimed before in the literature—this might prove useful in a routine laboratory dealing with postal samples; (3) the counts may be made as soon as the blood sample is taken; (4) by introducing small test-tubes in the diluting procedure, only one pipette is needed, and it can be used for all the blood samples.

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## Effect of the Rumen on Dietary Fat

Earlier experiments by Thomas, Culbertson and Beard[1] have shown that feeding liberal allowances of highly unsaturated oils to steer calves over a period of 260 days was without effect on the mean unsaturation of the body fat. It has similarly been shown by Shorland and co-workers[2–5] that the main dietary fatty constituent of pasture-fed animals—linolenic acid—although present in non-ruminants in quantity, appears only in traces in the depot fats of ruminants. It has been suggested by one of us that differences in fatty acid composition between the fats of ruminants and non-ruminants might be attributed to modification of the dietary fat in the rumen[3,5]. Reiser[6] found that linseed oil emulsions incubated with rumen contents showed a diminution in linolenic acid content with a corresponding increase in linoleic acid, indicating the hydrogenation of linolenic acid to linoleic acid. Hartman, Shorland and McDonald[7] have suggested that such hydrogenation would explain the presence of appreciable amounts (3·5–11·2 per cent) of *trans* acids in ruminant fats and their absence in the fats of non-ruminants.

More recently, in association with the Grasslands Division, Palmerston North, of the New Zealand Department of Scientific and Industrial Research, we have studied the effect of rumen contents on pasture fatty acids and on linolenic acid, and results now recorded serve to indicate the profound effect of the rumen on the dietary fat.

As previously observed[3], the predominant fatty constituent of pasture (cf. Table 1) is linolenic ($C_{18}$ triene) acid; but in the rumen fat, as in the ruminant depot fat, this acid is only a minor constituent. In the rumen the dietary fat has undergone a profound change, so that it now resembles depot fat. Particularly noteworthy are the high proportions of stearic acid. Hilditch[8] has already suggested that the relatively high proportions of stearic acid glycerides in ruminant depot fats could arise by hydrogenation *in situ* of preformed oleo-glycerides. The

Table 1. Comparison between Fatty Acid Composition of Clover-rich Pasture and of Rumen Contents of Sheep Grazing Thereon
(Fatty acids weight per cent)

| | Saturated | | | | Unsaturated | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $C_{14}$ | $C_{16}$ | $C_{18}$ | as $C_{22}$ | $C_{14}$ | $C_{18}$ | $C_{18}$ mono- | $C_{18}$ di- | $C_{18}$ tri-ene |
| Clover-rich pasture | — | 8·9 | 2·8 | 3·9 | — | 7·9 | 9·5 | 8·1 | 58·9 |
| Rumen contents of sheep | 1·2 | 16·9 | 48·5 | 5·8 | 0·2 | 1·8 | 19·4 | 2·9 | 3·3 |

present work, while by no means excluding this possibility, shows that stearic acid could arise also from the hydrogenation of dietary linolenic acid present as glyceride or as free acid in the rumen.

The results recorded in Table 1 do not exclude the possibility that the dietary fat is metabolized in the rumen and afterwards resynthesized. However, the following results obtained by incubation in a carbon dioxide atmosphere of 2·58 gm. linolenic acid (85 per cent pure, prepared from conophor oil) with rumen contents (144 ml.) for three days at 37° would suggest that this is not so to any marked degree.

The low content of fatty acids in the blank (0·47 gm.) and the relatively high proportion of fatty acids in the sample (2·46 gm.) remaining at the end of the experiment are consistent with the view that the fatty acids in the rumen are not appreciably destroyed, but that linolenic acid is hydrogenated to monoene as well as to diene acids to such an extent that, of the 2·19 gm. originally present, only 0·28 gm. remained. These results accord with Reiser's[6] view that rumen contents act as a powerful hydrogenating medium; but whereas he has suggested that linolenic acid is merely converted to linoleic acid, our work shows that the hydrogenation proceeds further to the monoene stage or to stearic acid (cf. also Table 1). The results in Table 2 establish also the accompanying formation of *trans* acids (cf. Hartman *et al.*[7]) during hydrogenation.

Table 2. Effect of Sheep Rumen Contents on Linolenic Acid (Weights of fatty acids in gm.)

| | Saturated | Monoene | Unsaturated Diene (*a*) | Triene (*a*) | Diene (*b*) | Triene (*b*) | *Trans* |
|---|---|---|---|---|---|---|---|
| Rumen contents + linolenic acid (sample) | 0·41 | 1·23 | trace | 0·28 | 0·50 | 0·04 | 0·26 |
| Rumen contents alone (Blank) | 0·32 | 0·15 | ,, | trace | trace | trace | Not detected |
| Difference | 0·09 | 1·08 | — | 0·28 | 0·50 | 0·04 | 0·26 |

(*a*) = non-conjugated, (*b*) = conjugated.

Work in progress shows that rumen contents also effectively hydrogenate linoleic and oleic acids. Details of this and of other experiments will be reported elsewhere.

The present results illustrate how the action of the rumen may modify the nature of the dietary fat before absorption and deposition. The extensive hydrogenation of the dietary fat in the rumen not only gives rise to *trans* acids, as earlier indicated by Hartman *et al.*[7], but it also explains the relative stability of the composition of ruminant depot fats independently of the nature of the dietary fat.

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## Behaviour of the Ground Substance of Rabbit Dermis in the Course of Skin Treatment with 3-4 Benzpyrene

It has been repeatedly observed that in the course of cell-growth processes of various nature (embryonic tissues[1], regenerating tissues in adult animals[2], tumours of epithelial and mesenchymal origin[3], etc.) the metachromatic substance is demonstrable, or increased if pre-existing, in the intercellular component of tissues. A relationship seems to exist between cell-growth processes and production of metachromatic substance in surrounding connective tissues; but its nature is unknown. We have therefore studied the genesis of intercellular metachromatic substances in the course of experimental oncogenesis, in order to establish whether their appearance is secondary to the already formed tumour or prior to its onset.

For this purpose seven albino rabbits were used. Their backs were carefully shaved; an area of approximately 15 cm. × 6 cm. on the right flank was painted with a 0·3 per cent solution of 3-4 benzpyrene in acetone (prepared by the Hoffman–La Roche firm of Basle), and an equally large area on the left flank was treated with acetone alone. Four applications were given at 3-day intervals. Three days after the last application, a skin fragment was removed from both benzpyrene- and acetone-treated surfaces. The fragments were fixed in ethanol at 90°. Microtome sections were stained with toluidine blue according to the usual technique for the demonstration of metachromatic substance.

The sections from the benzpyrene-treated skin presented, in addition to the epithelial alterations which are known to be characteristic of the early stages of skin carcinogenesis (hyperplasia of hair follicles, etc.), a remarkable increase of metachromatic substance of the dermis. This substance was especially evident in the upper layers of the dermis, particularly around the hyperplastic follicles. Nevertheless, some preparations showed that the metachromatic substance of the dermis was evidently increased in a uniform manner, even in the sites most remote from the follicles. The metachromatic substance became gradually less evident towards the skin deeper zones, so as to give a stain equal to that presented by the sections from the acetone-treated skin.

From these results it seems reasonable to conclude that the appearance of metachromatic substance is a consequence of the treatment with material which will later induce the onset of the tumour, rather than being due to the presence of the tumour itself, since at this stage of treatment there is no evidence of malignant metamorphosis in the epithelial cells. One cannot exclude also, at the present state of investigations, that in this case the increase of metachromatic substance, which occurs at the same time as the hyperplasia of epithelial structures, may have the same unknown significance as this phenomenon has in all the above-mentioned instances, that is, when the appearance of metachromatic substance is observed in the course of cell-growth processes.

This matter, however, seems to be significant and to deserve further investigations, because it is desirable to attempt a determination of the chemical nature of the metachromatic substance which is produced as a result of carcinogenic treatment.

In a recent paper by Sylvén[4], observations are reported which apparently deal with the same subject: he says that "In healing wounds the metachromatic material appeared simultaneously with a sharp decrease in mast cell numbers, and this is also illustrated during experimental mouse skin carcinogenesis". In the absence of the full account of this work, it is not possible to state whether his results are in accordance with ours.

This investigation has been carried out under the auspices of the Damon Runyon Memorial Fund for Cancer Research, New York.

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## Tumours induced in Rats with 4′-Fluoro-4-Aminodiphenyl

We have made the following suggestions to explain the incidence and location of the tumours produced in rats with 4-aminodiphenyl and some of its nuclear methylated derivatives[1]. First, that in each instance the effective carcinogen is the corresponding *ortho*-hydroxy amine, formed in the liver and excreted in the bile; secondly, that 4-aminodiphenyl itself is largely metabolized to the 4′-hydroxy derivative and that little of the *ortho*-hydroxy amine, 3-hydroxy-4-aminodiphenyl, is formed; and finally, that in the metabolism of the more actively carcinogenic derivatives of 4-aminodiphenyl containing a methyl substituent in the 3 position, relatively more of the corresponding *ortho*-hydroxy amines are produced.

Metabolic studies are in progress; in the meantime, we have sought indirect evidence in support of these ideas by preparing and testing 4′-fluoro-4-aminodiphenyl. With this substance the possibility of metabolic hydroxylation in the 4′-position is excluded by the presence there of firmly bound fluorine, and a relatively high yield of the corresponding 3-hydroxy-4-aminodiphenyl may be expected. If our theories are correct, this should result in increased carcinogenic potency on the part of the fluoro derivative in comparison with the parent amine of the series.

In a first experiment, 4′-fluoro-4-aminodiphenyl was given by subcutaneous injection, in solution in arachis oil B.P., to twenty-four male albino rats of Wistar origin. Injections were made daily, Saturday and Sunday excluded. The daily dose was initially 5 mgm./100 gm. body-weight; but because of toxicity it was reduced progressively over the first seven weeks of treatment to 1 mgm./100 gm. One rat died at 48 days, and for the remainder the mean overall duration of dosing was 143 days, the mean total dose of the compound 199 mgm./100 gm., and the mean survival time 515 days (limits 381 and 626) from the start of dosing. Neoplasms were found in every one of these twenty-three animals, the number in which the following organs were primarily involved being:

| | |
|---|---|
| Liver | 22 |
| Kidney | 20 (at least 10 bilaterally) |
| Intestine | 8 (6 large intestine only) |
| Pancreas | 3 (exocrine adenomata) |
| Testis | 3 (interstitial cell tumours) |

In addition, one animal had lymphosarcoma, one a spindle cell sarcoma in the mediastinum and three a subcutaneous sarcoma at the site of injection of the solution.

For eleven male and eleven female rats treated similarly with 4-aminodiphenyl itself, the mean duration of dosing was 306 days, the mean total dose 456 mgm./100 gm. and the mean survival time 477 days (limits 227 and 577). Tumours attributable to the compound were found in seven male and six female rats, apart from sarcomata local to the injection site and one sarcoma of the liver probably due to *Cysticercus fasciolaris*.

From this limited comparison it would appear that, quantitatively, the 4′-fluoro derivative is more actively carcinogenic than the parent amine. However, the introduction of the fluorine atom changes the whole pattern of tumour incidence. Whereas with 4-aminodiphenyl the commonest tumours were intestinal, such being found in seven of the thirteen tumour-bearing rats, the main targets of attack with the fluoro compound were the liver and kidney.

The changes seen in the liver in the latter animals comprised a variety of abnormalities leading up to hepatomata and cholangiomata. These often occurred together, and in some instances in remarkably complex and intimate mutual relationship. The tumours of the kidney were of tubular origin and ranged in size from the microscopic to masses 1·0–2·0 cm. in diameter. They were frequently multiple but appeared relatively benign; no metastases were found. A more detailed description of these tumours and their histogenesis is in preparation.

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## Loss of Biological Efficiency of Cattle-dipping Wash containing Benzene Hexachloride

Baths with capacities of several thousands of gallons are used in the principal cattle-raising countries in the control of ticks on cattle. The cost of the insecticide required to fill these baths is high, and the result is that they are used for one to two years, often longer, without being emptied and cleaned. As it is necessary, particularly in Africa, to dip large numbers of animals frequently, the baths become very foul. In 1946 benzene hexachloride (B.H.C.) was first used in South Africa for control; but its initial efficiency dropped rapidly in several baths, after use for a few months. Whitnall, Bradford, McHardy, Whitehead and Meerholz[1] reported inability to detect alteration in the γ-isomer content of such wash, but "the methods of chemical analyses used in their investigation were not specific for the γ-isomer" (Roulston and Hitchcock[2]). Technical B.H.C. containing about 13 per cent of the γ-isomer was being used, and the loss of efficiency was not proportional to the loss of total isomers. After fresh

Table 1

| Isomer | Initial B.H.C. (per cent) | Final B.H.C. (per cent) | Increase in ionized Cl (per cent) |
|---|---|---|---|
| alpha | 0·039 | 0·088 | 0·003 |
| beta | 0·099 | 0·097 | nil |
| gamma | 0·099 | 0·039 | 0·029 |
| delta | 0·039 | 0·075 | 0·007 |

insecticide restored initial efficiency, deterioration was then more rapid than before. Similar experience was reported wherever γ-isomer was only slightly in excess of that required for biological control. In Australia, where a much higher concentration was used, loss of efficiency was not observed in the field, although recent determinations by the partition chromatographic method show disproportionate loss of γ-isomer with loss of total isomers. Thus we have found in the B.H.C. contained in six samples from two baths in Queensland 2·9–7·8 per cent γ-isomer. The γ-isomer content of the B.H.C. used for these baths was approximately 12 per cent. Similar results are reported by Roulston and Hitchcock[2].

The cause of the loss of biological efficiency has been investigated in these laboratories for several years, and it has been shown that it is due to direct or indirect action by bacteria on the γ-isomer. Conditions in a cattle-dipping bath were imitated in a laboratory by adding fine soil, cattle fæces, urine and extracts of scrapings from cattle hide at weekly intervals to suspensions of finely ground B.H.C. Initially, technical B.H.C. (13 per cent γ-isomer) was used and biological efficiency was tested, using *Calandra granaria*. After a few months the loss was not proportional to the loss of total B.H.C. determined chemically by dehydrochlorination with alkali. Experiments with pure single isomers showed the γ-isomer to disappear at nearly six times the rate for the α-isomer. The results of this series of experiments after 68 weeks are given in Table 1.

Losses of unchanged isomers occasioned by volatility during the period of these experiments were estimated to be: α, 0·004 per cent; β, nil; γ, 0·007 per cent and δ, 0·006 per cent.

The rates of decomposition of the α- and γ-isomers differed from those of these isomers when they are dehydrochlorinated by treatment with alkali[3]. Nakajima, Inagaki and Tati[4] found the γ-isomer gives benzene at a greater rate than the α-isomer by the action of zinc powder in aqueous alcohol.

Further evidence of the unusual mechanism of breakdown came from the observed more rapid increase in the ionized chlorine contents of preparations of the γ-isomer than of those of the α-isomer. After 50–70 weeks, five to six atoms of ionized chlorine had been obtained from each molecule of the γ-isomer destroyed, but approximately only three from each of the α-isomer. The results of one series of experiments are given in Table 1, column 4.

Bacterial action appeared to be the only explanation for these results. A range of organisms was therefore grown with pure γ-isomer in peptone-serum broth; the growth of the anaerobes particularly was accompanied by substantial destruction of benzene hexachloride.

Table 2

| | Initial total B.H.C. (per cent) | Final B.H.C. (per cent) | Gamma isomer recovered unchanged (per cent) |
|---|---|---|---|
| Control (no chlorate) | 0·103 | 0·084 | 18 |
| Exp. 1 (chlorate added) | 0·100 | 0·098 | 88 |
| Exp. 2 (chlorate added) | 0·101 | 0·097 | 82 |

If the hydrogen produced by certain bacteria could dechlorinate B.H.C., an explanation for the observed facts would be forthcoming. Gases produced from cultures of *Cl. sporogenes* and *B. coli* in suspensions of pure γ-isomer were led through a mixture of nitric and sulphuric acids, and at intervals nitrogen was passed through the cultures and apparatus. Traces of benzene were usually detected in the head space within seven days, with further quantities appearing regularly until the growth-rate of the bacteria became slow. The benzene was estimated by the method of Schechter and Hornstein[5]. In addition to the *m*-dinitrobenzene recovered, a small amount of dinitro-chlorbenzene was also detected in one experiment; this was identified by the colour produced with pyridine and sodium hydroxide[6]. Benzene had also been detected in samples of cattle wash obtained from South Africa, and no benzene was produced in controls to which no B.H.C. was added.

It appears probable that hydrogen produced by bacteria brings about dechlorination of the γ-isomer and, to a slight extent, of the α-isomer.

Confirmation appears to come from experiments in which, after adding fouling materials to suspensions of benzene hexachloride (11–12 per cent γ-isomer), sodium chlorate (0·1 per cent) was added to each preparation initially and at monthly intervals. To a control preparation no chlorate was added. The results of analysis after fifty weeks are given in Table 2.

This work has been carried out by a number of entomological, chemical and bacteriological workers in these laboratories with the co-operation of their colleagues in South Africa and Australia. It is proposed to publish fuller results elsewhere.

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## Biochemical Variations in Inbred Mice

Attention has been directed to skeletal variations within inbred mice strains by Grüneberg[1] and by McLaren and Michie[2]. The latter workers have surveyed most of the available substrains of $C_3H$ mice and have found that they fall into two general categories having either five or six lumbar vertebræ. In the course of studies on the response of liver β-glucuronidase to hormone injections, it has now been found that there are two quite distinct levels of this enzyme in certain $C_3H$ substrains, and that this difference represents a genetical variation in the $C_3H$ strain.

Fishman and Farmelant[3] and Law, Morrow and Greenspan[4] have previously observed that there are two general levels of activity in inbred strains, a

Table 1

| $C_3H$ substrain | | Liver glucuronidase activity |
|---|---|---|
| Two substrains derived before 1938 in the United States | | 220<br>250 |
| Imperial Cancer Research Fund | (1941) | 220 |
| Leeds | (1942) | 300 |
| Glasgow | (1948) | 2,910 |
| Birmingham | (1950) | 3,150 |
| Chester Beatty | (present stock) | 2,520 |

'high' level of about 3,000–4,000 units in most strains tested, but also a 'low' level, 250–400 units, in $C_3H$ and *AKR* strains (units: μgm. phenolphthalein liberated from phenolphthalein glucuronide per hr. per gm. wet tissue[5]). In Table 1 are listed the liver glucuronidase activities determined in a number of $C_3H$ substrains at present kept in Britain. All are descended from a group of $C_3H/Bi$ (Bar Harbor) originally supplied to the Chester Beatty Institute in 1938, the dates of separation from this line being shown in brackets.

Two substrains separated before 1942 belong to the expected low group; but the other three substrains, including the original line, have high glucuronidase levels. It would therefore appear that some change or mutation, which finds expression as this difference in enzyme activity, took place in the Chester Beatty stock between 1942 and 1948. In view of these observations the possibility that other similar biochemical variations in inbred strains may occur must be taken into account when comparing results obtained on supposedly 'pure' strains by different workers.

It is not known in this case whether there is any difference in the incidence of spontaneous mammary tumours in these 'high' and 'low' substrains; but this is being investigated. By crossing a high strain (Strong *A*) with a low one ($C_3H$), Law *et al.*[4] showed that the presence of high glucuronidase activity was associated with a single dominant gene. Cross-breeding experiments between 'high' and 'low' $C_3H$ substrains and between $C_{57}$ (high) and $C_3H$ (low) have confirmed this observation.

I wish to thank Drs. J. Craigie, L. Foulds and P. R. Peacock, who supplied mice from their stocks for measurement, and Dr. Anne McLaren for supplying hybrid mice and information about the origin of the $C_3H$ substrains prior to publication[2].

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## Potentiating Action of Chlorpromazine and Reserpine

This laboratory has previously reported that β-diethylaminoethyl diphenylpropylacetate hydrochloride (*SKF 525-A*) potentiates the pharmacological activity of a variety of drugs by interfering with their rate of detoxication[1,2]. Recently, we have become interested in the potentiating effects of chlorpromazine and reserpine, drugs widely used for their tranquillizing effects. Chlorpromazine is reported

Table 1. Influence of Chlorpromazine on Duration of Action and Metabolism of Hexobarbitone and Ethanol in Mice
Adult male mice received, intraperitoneally, hexobarbitone (100 mgm./kgm.) or ethanol (4 gm./kgm. in 50 per cent solution) together with chlorpromazine (5 mgm./kgm.). Mice given the hypnotics without chlorpromazine served as controls. The animals assayed for hexobarbitone were killed 20 min. after drug administration; those assayed for ethanol were killed after 30 min. Figures in brackets refer to number of animals in each series

| Drug | Duration of hypnosis*† (min.) | | Drug metabolized at death† (per cent) | |
|---|---|---|---|---|
| | Controls | Chlorpromazine treated | Controls | Chlorpromazine treated |
| Hexobarbitone | 19±6 (12) | 46±8 (12) | 56±4 (5) | 59±4 (5) |
| Ethanol | 40±9 (9) | 150±13 (6) | 29±1 (6) | 28±2 (6) |

* Time from loss to return of righting reflex
† Mean ± standard deviation

to potentiate the action of a number of central depressant drugs, including barbiturates and ethanol[3]. We have been able to show that reserpine as well as chlorpromazine potentiates the hypnotic action of hexobarbitone and ethanol; and furthermore, that neither potentiating agent influences the rate of metabolic transformation of the hypnotics but acts presumably by increasing the sensitivity of the central nervous system.

The sleeping times of mice injected with chlorpromazine and hexobarbitone were compared with those of mice injected with hexobarbitone alone. Table 1 shows that mice given 100 mgm. per kgm. of hexobarbitone together with 5 mgm. per kgm. chlorpromazine slept considerably longer than animals given only the barbiturate.

In another series of mice, the effect of chlorpromazine on the rate of bio-transformation of hexobarbitone was investigated. At a given time, the animals were killed by a blow on the head, homogenized in a Waring blendor in four volumes of phosphate buffer, *p*H 7, and the concentration of barbiturate assayed in an aliquot of the homogenate by a method previously described[1]. As shown in Table 1, chlorpromazine did not influence the metabolism of the barbiturate. Table 1 also indicates that chlorpromazine potentiated the hypnotic action of ethanol, again without changing the rate of metabolic transformation. In these experiments ethanol was assayed enzymatically in the whole animal homogenate, according to the method of Bucher and Rodetski[4].

Chlorpromazine by itself in a dose of 5 mgm. per kgm. produced only a mild sedation, and even ten times this dose failed to produce hypnosis.

It was determined that chlorpromazine did not exert its potentiating effects by changing the uptake

Table 2. Influence of Reserpine on Duration of Action and Metabolism of Hexobarbitone and Ethanol in Mice
Adult male mice received, intraperitoneally, reserpine (5 mgm./kgm.) and, 1 hr. later, hexobarbitone (100 mgm./kgm.) or ethanol (4 gm./kgm. in 50 per cent solution). Mice given the hypnotics alone served as controls. The animals assayed for hexobarbitone were killed 30 min. after barbiturate administration; those assayed for ethanol were killed after 120 min. All animals were kept at 35° C. to minimize the hypothermia otherwise produced by pretreatment with reserpine. Figures in brackets refer to number of animals in each series

| Drug | Duration of hypnosis*† (min.) | | Drug metabolized at death† (per cent) | |
|---|---|---|---|---|
| | Controls | Reserpine treated | Controls | Reserpine treated |
| Hexobarbitone | 19±6 (12) | 68±14 (7) | 46±3 (3) | 48±3 (3) |
| Ethanol | 40±9 (9) | All>300 (6) | 48±3 (5) | 45±6 (5) |

* Time from loss to return of righting reflex
† Mean ± standard deviation

of the hypnotics by the brain. Animals killed at various times after injection of the hypnotics showed no significant difference in the concentration of barbiturate or alcohol in the brain, regardless of whether or not the animals had also received chlorpromazine. This indicated that the effects of the potentiator did not result from an increased concentration of the hypnotics in the brain.

Reserpine, which exerts tranquillizing effects similar to those observed with chlorpromazine, was also found to potentiate markedly the effects of hexobarbitone and ethanol. Its effect on the latter compound was especially striking (Table 2). Like chlorpromazine, reserpine did not affect the rate of bio-transformation of the two hypnotics (Table 2) or alter their uptake by the brain.

The mode of potentiation induced by chlorpromazine and reserpine is obviously different from that of *SKF* 525-*A*. This difference was shown in another way. When *SKF* 525-*A* was given intravenously to mice or dogs which had just recovered from hypnosis induced by hexobarbitone, the animals were not visibly affected; but if chlorpromazine was given, the animals reverted almost immediately to a deep hypnosis. This shows that chlorpromazine causes subhypnotic amounts of hexobarbitone to become hypnotic, and is therefore a true potentiator, in contrast to *SKF* 525-*A*, which acts merely as a prolonging agent.

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## Phosphorylase Activity in Relation to the Layering of Starch Granules

Arthur Meyer firmly believed that the layering of starch granules corresponded to the alternation of day and night, and this belief is still shared by the authors of modern text-books. If this were true, then layers should disappear when starch granules develop under constant outer conditions of illumination, temperature and moisture. The only positive result of such an experiment was reported by van de Sande-Bakhuyzen for wheat. All other results appear to be negative. Salter found layers when starch granules grew in darkness, Fischer observed them after constant illumination, and according to Küster more than two layers could be deposited during one day.

Recently, similar results have been obtained for potato starch with more accurate methods[1]. Therefore, the layers must be deposited as the result of an inner rhythmic process, which, of course, might accidentally coincide with an outer rhythm. One possibility would be a fluctuation in enzymatic activity, as suggested by Bünning and Hess[1]. A day–night periodicity has been reported by Russian investigators for the phosphorylase activity of potatoes, and Shaw[2] mentions the possibility of a seasonal fluctuation in wheat under the influence of light.

We have measured phosphorylase activity in young actively growing potatoes of about 1·5 cm. diameter during 24-hr. periods at 6-hr. intervals. Stem cuttings of potato plants were planted in washed river sand in a greenhouse and allowed to root and form small tubers. All cuttings were grown in one container and received the same treatment. 20–30 gm. sliced tubers were treated with cold sodium hydrosulphite, extracted with 0·05 *M* cold citrate buffer *p*H 6·5 in a blendor for 3 min., the extract filtered and centrifuged. 1 ml. of the extract was allowed to react with 1 ml. of substrate containing sodium fluoride, mercuric chloride, soluble starch and glucose-1-phosphate in quantities indicated by the work of Porter[3]. The *p*H was kept at 6·5 with citrate buffer and the temperature at 30° C. After 5 min., the reaction was stopped with cold trichloroacetic acid, the *p*H of the mixture brought down to 4 with sodium acetate, and inorganic phosphate estimated by the method of Waygood[4]. All determinations were done in duplicate. The results of two series, one starting at 6 a.m., the other starting at 10 a.m., are given in Table 1.

Table 1

| Time of sampling | Phos./min./gm. fresh weight I | II |
|---|---|---|
| 0 | 36·6 | |
| 4 | | 31·2 |
| 6 | 34·3 | |
| 10 | | 33·0 |
| 12 | 32·4 | |
| 16 | | 33·8 |
| 18 | 37·4 | |
| 22 | | 31·5 |

The results do not show an appreciable diurnal variation of phosphorylase activity, and therefore it is more likely that the shells of a starch granule find their origin in rhythmic depositions conditioned, for example, by periodically occurring diffusion gradients.

As it has now been well established that phosphorylase is located in the plastids, but that it escapes from these structures as soon as the cells are damaged[2], we can assume that determinations in extracts from comminuted materials give the total amount of phosphorylase available. However, as Russian investigators (cited by Weier and Stocking[5]) noticed stronger absorption of invertase by plastids in the light than in the dark, the possibility of similar rhythmic processes in the plastids of the potato cannot be entirely excluded. It is also possible that, as indicated by recent work[6], phosphorylase is less involved in starch synthesis than we hitherto thought.

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## Effect of Particle-Size on the Quantitative Determination of Quartz by X-ray Diffraction

A GEIGER–MÜLLER counter X-ray diffractometer has been built in this laboratory[1] for the quantitative analysis of mineral dusts. One of the first tasks of this apparatus was the measurement of quartz content in airborne dusts, lung residues and similar material arising in silicosis research. It was therefore necessary to examine the accuracy with which such determinations can be made, and in particular the effect on their accuracy of the particle-size of the quartz.

Closely graded size-fractions were prepared by repeated sedimentation or centrifuging; their size-distributions were determined by optical or electron microscopy, and the mean size $\bar{d}$ of each fraction expressed in the form $\bar{d} = \Sigma n_d d^3 / \Sigma n_d d^2$, where $n_d$ is the number of particles in a small size-range of mean diameter $d$. The peak intensities of the $11\bar{2}2$ line of quartz (spacing 1·82 A.) are shown as a function of $\bar{d}$ in Fig. 1; they reach a maximum at $\bar{d} = 2\mu$ approximately, and fall off for $\bar{d}$ both larger and smaller than this value. The lower intensities for larger particle-sizes are to be expected as a result of extinction; those at smaller sizes are attributed to the existence of the 'amorphous layer' previously reported[2]. The broken part of the curve refers to samples from which an attempt has been made to remove the 'amorphous' layer by etching with hydrofluoric acid. (The sizes of the etched samples were determined afresh by microscopy.)

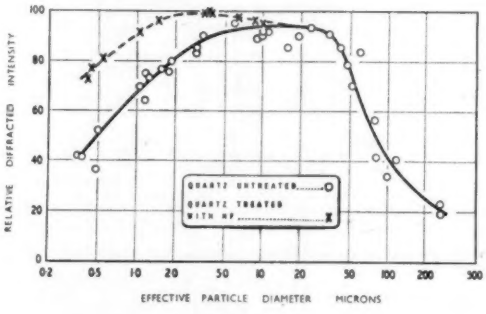


Fig. 1

The effects of this 'layer' have been since studied in detail, and results to be published elsewhere suggest that it is not a clearly defined amorphous shell surrounding perfectly crystalline material, but rather that a gradual increase in crystallinity occurs from the surface of a particle towards the interior. This idea is confirmed by the fact that for particles less than 0·5$\mu$ in size the full intensity of the diffraction line is not reached after etching; these particles are presumably too small for the crystal lattice to be undisturbed even at the centre. A few measurements, in which integrated areas of diffraction lines were measured, confirmed these observations; the total reduction in integrated intensity at small particle-sizes is somewhat less than that in peak intensity, since the peak measurement is affected to some extent by particle-size line-broadening; but it is not possible to account for the whole reduction in peak intensity in this way.

Thus in order to make accurate determinations of quartz by X-ray diffraction, it is necessary to know its particle-size distribution and, possibly, whether it has received treatment equivalent to etching. In the size range 1–20$\mu$, the error introduced by ignoring these effects is of the order of 12 per cent; for correlation with medical studies this error is insignificant.

We wish to thank Mr. J. Cartwright of this laboratory, who determined the particle-size distributions, and to acknowledge the experimental assistance of Mr. B. Russell and Miss A. V. Sanderson. Our thanks are due to the Director of the Safety in Mines Research Establishment and the Ministry of Fuel and Power for permission to publish this communication.

R. L. GORDON
G. W. HARRIS
Safety in Mines Research Establishment,
Sheffield 1.
Feb. 28.

[1] Arndt, U. W., and Nelson, J. B., *Brit. J. App. Phys.*, **5**, 417 (1954). Gordon, R. L., and Harris, G. W., Safety in Mines Research Establishment Research Report No. 137 (in preparation).

[2] Nagelschmidt, G., Gordon, R. L., and Griffin, O. G., *Nature*, **169**, 539 (1952). Gordon, R. L., Griffin, O. G., and Nagelschmidt, G., Safety in Mines Research Establishment Research Report No. 52 (1952).

## Unusual Waveguide Characteristics associated with the Apparent Negative Permeability obtainable in Ferrites

*B* AND *H* in a magnetized ferrite material are related, not by a scalar permeability, but by a tensor of the form:

$$\begin{Vmatrix} \mu & -jk & 0 \\ jk & \mu & 0 \\ 0 & 0 & \mu_z \end{Vmatrix}$$

where $z$ is the direction of the magnetization[1]. If a plane wave is propagated along the $z$ direction and is circularly polarized, the permeability associated with the transverse components in the $xy$ plane assumes the form:

$$B_t = (\mu \pm k) H_t$$

where the sign depends on the direction of the circular polarization. In many ferrites at 10,000 Mc./s., $k$ is greater than $\mu$ and the effective permeability for right-handed polarization about the field direction is negative. The propagation constant, which is proportional to the square root of the permeability, is imaginary and the wave is evanescent.

However, an interesting case occurs if such a wave is generated in a waveguide. In order that the electric field at the wall should be zero, a transverse variation of field arises, and for *H*-modes this is associated with the longitudinal permeability $\mu_z$, which is of the order unity and is positive. If it is assumed that the transverse permeability $(\mu - k)$ is unaffected by the guide walls, which is qualitatively justified by the rigorous theory of Suhl and Walker[2], the propagation constant in the ferrite, $\gamma_g$, follows from the equation:

$$\frac{\gamma_g^2}{k-\mu} = \frac{\gamma_t^2}{\mu_z} - \gamma_0^2 \varepsilon$$

where $\gamma_0$ is the free-space propagation constant and $\gamma_t$ is inversely proportional to the size of guide, and $\varepsilon$ is the dielectric constant of the ferrite. For a waveguide of very large size $\gamma_g$ is imaginary, and the wave is evanescent. As the size of guide is reduced, so the attenuation decreases until a critical point is reached

corresponding to the cut-off in an isotropic material of permeability $\mu_z$. Beyond this, $\gamma_g$ becomes positive and the wave is propagated. This propagation should continue down to zero waveguide size, and the guide wave-length will decrease progressively and indefinitely. It can also be shown that the group velocity of the wave is negative and therefore that the wave travel is in the opposite direction to the energy flow.

Results of an experimental investigation on two sizes of ferrite-filled circular waveguide are shown in Fig. 1. The diameters were 1/8 in. and 9/16 in. respectively, below and above the cut-off diameter at 10,000 Mc./s. as normally calculated, assuming an isotropic permeability equal to $\mu_z$. The attenuation is plotted against magnetic field. The full curves for positive field refer to the case where the effective transverse permeability is negative, and it is apparent that the attenuation is greater through the large-diameter waveguide. The dotted curve for negative field is of the normal type for positive permeabilities, and the small waveguide is beyond cut-off. It was also confirmed experimentally that in the anomalous propagation in the 1/8-in. diameter guide the phase velocity was negative.

Experiments were not carried out on the effect of varying the wave-length; but it would be expected that the small-diameter waveguides would continue to propagate as the frequency is reduced over the whole range that $\mu - k$ is negative. This lies between the gyromagnetic resonance frequency, given by $\omega = \gamma H$, and the inversion frequency given by $\omega = \gamma B$, where $\gamma$ is the gyromagnetic ratio of the electron, and $H$ and $B$ are the magnetic field and induction, respectively, in the ferrite.

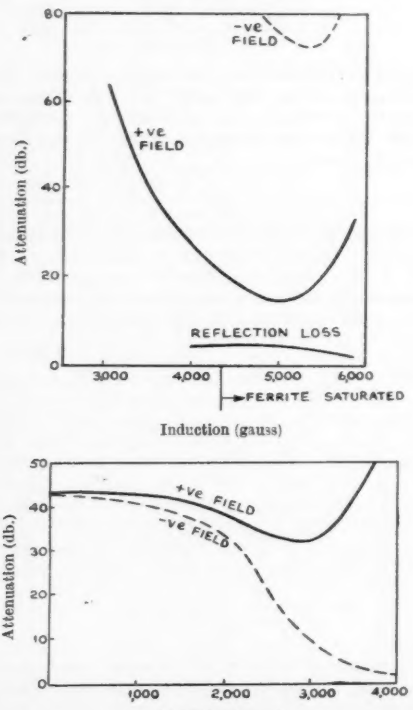


Fig. 1. Specimens of ferroxcube *B2* at 10,200 Mc./s., with the following diameters: 0·125 in. (upper graph); 0·562 in. (lower graph)

G. H. B. Thompson
Standard Telecommunication Laboratories, Ltd.,
Progress Way, Great Cambridge Road,
Enfield, Middlesex. April 14.

[1] Polder, D., *Phil. Mag.*, **40**, 99 (1949).
[2] Suhl, H., and Walker, L. R., *Bell System Tech. J.*, **33**, No. 3, 579.

## A Double-walled Vessel for the Distillation of Highly Inflammable Liquids

The apparatus described below[1] provides a safe means of distilling or refluxing highly inflammable liquids. It has the added advantages of heat economy and the avoidance of bumping. The inner portion *A* of a double-walled vessel (Fig. 1) contains the liquid to be distilled or refluxed, *C*, and is connected by joint *G* to a condenser in the appropriate position. The outer portion *B* is connected to a reflux condenser *E* and contains, therefore, only a small amount of inert non-inflammable heating liquid *D*, with a boiling point slightly in excess of that of *C*. In view of the enclosed nature of the heating bath, a surprisingly small external heat source suffices, and very even heating of the entire vessel *A* occurs with little bumping.

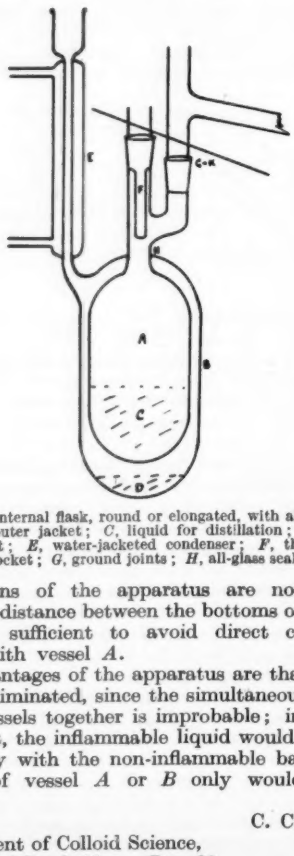


Fig. 1. *A*, internal flask, round or elongated, with all-glass seal at *H*; *B*, outer jacket; *C*, liquid for distillation; *D*, higher boiling point; *E*, water-jacketed condenser; *F*, thermometer pocket; *G*, ground joints; *H*, all-glass seal

Dimensions of the apparatus are not critical, though the distance between the bottoms of *A* and *B* should be sufficient to avoid direct contact of liquid *D* with vessel *A*.

The advantages of the apparatus are that fire risk is largely eliminated, since the simultaneous fracture of both vessels together is improbable; in this unlikely event, the inflammable liquid would be mixed immediately with the non-inflammable bath liquid. A break of vessel *A* or *B* only would not be dangerous.

C. C. Smith
Department of Colloid Science,
University of Cambridge. Jan. 21.

[1] Provisional Brit. Patent No. 30407.

# FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

## Tuesday, June 28

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Psychology Department, Birkbeck College, Malet Street, London, W.C.1), at 7 p.m.—Dr. Gustav Jahoda: "Some Social Implications of Cultural Differences in Mental Abilities".

## Tuesday, June 28—Saturday, July 9

BRITISH INSTRUMENT INDUSTRIES EXHIBITION (at Earls Court, London, S.W.).*

## Wednesday, June 29

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. M. H. P. Bott: "A Geophysical Study of the Granite Problem"; Mr. G. E. Thomas and Mr. T. M. Thomas: "The Volcanic Rocks of the Fishguard-Strumble Head Area, Pembrokeshire".

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (in the restaurant room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Micro-determination of Molecular Weight".

## Thursday, June 30

INSTITUTE OF PETROLEUM (in arrangement with the U.S. Co-ordinating RESEARCH COUNCIL, at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 3.30 and 5.30 p.m.—Mr. M. K. McLeod, Mr. T. B. Rendel, Mr. E. S. MacPherson and Mr. W. J. Sweeney: "The Story of the Co-ordinating Research Council".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. R. Clarke: "Influence of Numbers on Reproduction and Survival in Two Experimental Vole Populations"; Mr. J. E. Morton: "The Functional Morphology of the British Ellobiidae".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHAIR OF MEDICINE tenable at St. Bartholomew's Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 28).

ASSISTANT EXPERIMENTAL OFFICER or EXPERIMENTAL OFFICER (with a pass degree in chemistry or physics or equivalent qualification) at the Agricultural Research Council's Unit of Embryology at Bangor, to assist in serological investigations using radioactive isotopes—The Director, Unit of Embryology, University College of North Wales, Bangor (June 30).

ASSISTANT LECTURER (Taxonomist) IN THE DEPARTMENT OF BOTANY; an ASSISTANT LECTURER IN SOIL SCIENCE; an ASSISTANT LECTURER (with special interests in the theory of solids or metals) IN THE DEPARTMENT OF APPLIED MATHEMATICS; an ASSISTANT LECTURER IN THE DEPARTMENT OF PURE MATHEMATICS; and an ASSISTANT LECTURER IN THE DEPARTMENT OF AGRICULTURE (Animal Husbandry)—The Registrar, University College of Wales, Aberystwyth (June 30).

ASSISTANT (with an honours degree in physiology or biochemistry) IN PHYSIOLOGY at St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (June 30).

BIOCHEMIST (British nationality, with an honours degree in biochemistry or agricultural chemistry and at least five years post-graduate experience in biochemical work) IN THE VETERINARY RESEARCH DIVISION of the Ministry of Agriculture, Stormont, Belfast—The Secretary, Civil Service Commission, Stormont, Belfast (June 30).

BIOMETRICIAN (with either a first degree in mathematics with subsequent appropriate training in biology, or a degree in some branch of science with subsequent training in biometry and/or statistical and experimental method) IN THE DEPARTMENT OF AGRICULTURE—The Registrar, King's College, Newcastle-upon-Tyne (June 30).

RESEARCH FELLOW IN ASTRONOMY or ASTROPHYSICS—The Secretary, University College, Exeter (June 30).

RESEARCH OFFICER IN CYTOLOGY, and a DEPARTMENTAL DEMONSTRATOR IN CYTOLOGY—Prof. C. D. Darlington, Botany Department, The University, Oxford (June 30).

SECOND ASSISTANT ANALYST (with a degree or A.R.I.C.)—The Borough Analyst, Civic Centre, Southampton (June 30).

SENIOR BIOCHEMIST (with a first- or second-class honours science degree or A.R.I.C.) IN THE RESEARCH LABORATORY, RHEUMATISM RESEARCH UNIT—The Secretary, Bath Hospital Management Committee, Manor Hospital, Bath (June 30).

ZOOLOGIST at the Dove Marine Laboratory—The Registrar, King's College, Newcastle-upon-Tyne (June 30).

ASSISTANT (with an honours degree in electrical engineering and preferably with research experience) IN THE DEPARTMENT OF ENGINEERING—The Secretary, The University, Edinburgh (July 1).

LECTURER IN THE DEPARTMENT OF PHYSICS, and an ASSISTANT LECTURER IN THE DEPARTMENT OF ZOOLOGY—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1 (July 1).

ASSISTANT LECTURER (with qualifications in physical and inorganic chemistry) IN CHEMISTRY—The Registrar, The University, Hull (July 2).

ASSISTANT LECTURER (preferably female) IN ORGANIC CHEMISTRY—The Principal, Royal Holloway College, Englefield Green, Surrey (July 4).

ASSISTANT, Grade B (with a good honours degree in mathematics of a British university, and preferably with teaching experience) IN THE DEPARTMENT OF MATHEMATICS—The Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11 (July 5).

ASSISTANT LECTURER (graduate in physics, chemistry, metallurgy, biology or engineering) IN DENTAL MATERIALS—The Registrar, The University, Manchester (July 6).

LECTURER IN AGRICULTURAL BOTANY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 6).

CHEMIST (with a good honours degree or equivalent qualification) IN THE COAL SURVEY LABORATORY, Newcastle-upon-Tyne, for analytical investigational work—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting SS/1 (July 7).

ASSISTANT, Grade B (with a good honours degree in chemistry and preferably with teaching experience)—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (July 9).

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Sheffield (July 9).

ENGLISH ELECTRIC COMPANY RESEARCH FELLOW (graduate in engineering or applied science) IN AERONAUTICS—The Secretary of University Court, The University, Glasgow (July 9).

LECTURER IN GEOLOGY—The Registrar, The University, Nottingham (July 9).

LECTURER IN THE DEPARTMENT OF ELECTRONIC ENGINEERING, and a LECTURER IN THE DEPARTMENT OF ELECTRIC POWER ENGINEERING—The Registrar, The University, Liverpool (July 9).

LECTURER IN CHEMISTRY; an ASSISTANT LECTURER IN PHYSICS; an ASSISTANT LECTURER IN BIOLOGY; and an ASSISTANT LECTURER IN GEOLOGY at the Royal Technical College of East Africa, Nairobi—The Secretary, Advisory Committee on Colonial Colleges, 1 Gordon Square, London, W.C.1 (July 11).

ASSISTANT ZOOLOGIST (with an honours degree in zoology or specialized in entomology or plant nematology) for work in connexion with the beet eelworm and related species of cyst-forming nematodes and will include a study of population dynamics—The Secretary, School of Agriculture, University of Cambridge (July 13).

ASSISTANT LECTURER (Grade III) or DEMONSTRATOR IN PHARMACOLOGY—The Registrar, The University, Bristol 8 (July 15).

LECTURER IN MECHANICAL ENGINEERING, and a LECTURER IN PHYSICS at the University of Natal, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 15).

LECTURERS (2) (with an honours degree) IN PHYSICS at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1 (July 15).

RESEARCH OFFICER—PHYSICIST (with a university honours degree in science with physics as a major subject, or equivalent qualifications, and some research experience in physics or physical meteorology) IN THE DIVISION OF METEOROLOGICAL PHYSICS, Commonwealth Scientific and Industrial Research Organization, Aspendale (near Melbourne), Victoria, for research into turbulent transfer processes in the atmosphere with emphasis initially on the experimental study of interchange of energy between atmosphere and ocean, including observational work at sea—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 470/73 (July 16).

SENIOR RESEARCH FELLOW (with Ph.D. or equivalent qualification, and preferably with some experience in cement chemistry and/or X-ray crystallography), and a JUNIOR RESEARCH STUDENT, IN THE DEPARTMENT OF CHEMISTRY, to carry out fundamental research on the chemistry of cement and cement products—The Secretary, Marischal College, University of Aberdeen (July 16).

SENIOR RESEARCH OFFICER or RESEARCH OFFICER (with a university honours degree, with chemistry or chemical engineering or metallurgy as a major subject, and preferably with evidence of post-graduate experience and research ability) IN THE DIVISION OF INDUSTRIAL CHEMISTRY, Melbourne, to conduct research into problems associated with the processing of a wide variety of Australian uranium ores—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 590/555 (July 16).

CHAIR OF CHEMISTRY tenable at Royal Holloway College—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 20).

ASSISTANT LECTURER IN ZOOLOGY—The Registrar, The University, Reading (July 22).

BOTANIST (preferably with an honours degree in agricultural botany and two years postgraduate experience, or at least a degree in agriculture) IN THE BOTANICAL DIVISION, Rubber Research Institute of Malaya, Kuala Lumpur, to take charge of field experiments and to assist with advisory work—The Secretary, Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London, S.W.7 (July 30).

RESEARCH OFFICER (with a university honours degree in science or agricultural science, research experience in pasture ecology and/or animal husbandry) IN THE LAND RESEARCH AND REGIONAL SURVEY SECTION, Commonwealth Scientific and Industrial Research Organization, Katherine, Northern Territory, to conduct studies on animal production based on the utilization of native pastures, supplemented by the by-products of a tropical dry monsoonal farming system—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 571/24 (July 30).

SENIOR LECTURER IN AGRICULTURE—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (July 30).

JOHN HOLT DIRECTOR OF BIOCHEMICAL RESEARCH in the St. Vincent's Hospital School of Medical Research (University of Melbourne)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 20).

DIRECTOR (with high scientific attainments, administrative ability and experience) OF THE INDIAN INSTITUTE OF SCIENCE—The Registrar, Indian Institute of Science, Bangalore 3, India (September 5).

SENIOR LECTURER (with a good honours degree or higher degree in engineering and some experience in the application of the principles of applied mechanics and stress analysis to machinery and mechanical structures, and preferably with industrial experience) IN MECHANICAL ENGINEERING at the University of Queensland,

Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 20).

ASSISTANT EXPERIMENTAL OFFICERS or EXPERIMENTAL OFFICERS (with at least H.S.C. (science) or equivalent) at the Royal Aircraft Establishment, Farnborough, Hants, to assist in development of optical instrumentation used in guided weapons trials—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.395/5A.

ASSISTANT, Grade B, IN PHARMACEUTICAL CHEMISTRY at the Technical College, Bradford—The Director of Education, Town Hall, Bradford.

BACTERIOLOGIST (university trained and with practical laboratory experience) to carry out laboratory work in connexion with the production of veterinary sera and vaccines—The Bayer Biological Institute, Exning, Newmarket.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (with H.S.C. or equivalent qualifications and preferably with a knowledge of physical chemistry and/or chemical engineering experience), to assist in investigations in the physico-chemical properties of high explosives, and in the application of the results to the production of charges on plant scale—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 284/WGE/34.

EXPERIMENTAL OFFICER (preferably with a degree in chemical engineering, or at least Inter.B.Sc., or H.N.C. in chemical engineering and experience in the operation of experimental plants and an understanding of chemical engineering principles), to take part in the design and development of special plants involving the testing of prototype equipment and assist in developing the final plant designs—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 578/WGE/34.

GRADUATE RESEARCH OFFICER (preferably well qualified in mineralogy) IN THE REFRACTORIES SECTION OF THE CHEMISTRY DEPARTMENT, for laboratory and field work on slag utilization—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Slags".

HEAD OF THE DEPARTMENT OF CHEMISTRY (including colour chemistry and dyeing)—The Principal, Technical College, Queen Street South, Huddersfield.

LECTURER and ASSISTANT LECTURER IN APPLIED PHYSICS—The Secretary, Royal Technical College, Glasgow.

LECTURER (Grade II) IN BIOLOGICAL ENGINEERING—The Registrar, The University, Birmingham 15.

LECTURER IN MATHEMATICS; an ASSISTANT (Grade B) IN BIOLOGY; and an ASSISTANT (Grade B) IN PHYSICS—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

SENIOR LECTURER IN ELECTRONICS; a LECTURER IN ELECTRICAL MEASUREMENTS; and a LECTURER IN ELECTRICAL (Light Current) ENGINEERING—The Clerk to the Governing Body, Battersea Polytechnic, London, S.W.11.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Department of Scientific and Industrial Research: Building Research Station. National Building Studies. Research Paper No. 21: Studies on Bridge-deck Systems. 1: Tests on a Model Jack-Arch Slab. By A. Short and R. I. Lewis. Pp. vi+70+4 plates. (London: H.M. Stationery Office, 1955.) 4*s*. net. [284

Nickel and Nickel Alloys in Electronic Valves. Pp. 20. (London: Henry Wiggin and Co., Ltd., 1955.) [284

Building Research Station Digest No. 75: Strength and Stability of Walls. Pp. 7. (London: H.M. Stationery Office, 1955.) 3*d*. net. [284

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 936, Vol. 247, (26 April 1955): An Electrically Calibrated Bomb Calorimeter. By A. R. Challoner, H. A. Gundry and A. R. Meetham. Pp. 553–582. 9*s*. No. 937, Vol. 248, (26 April 1955): The de Haas–van Alphen Effect. 3: Experiments at Fields up to 32kG. By J. S. Dhillon and D. Schoenberg. Pp. 21. 6*s*. 6*d*. (London: Royal Society, 1955.) [284

Privy Council. Medical Research Council Special Report Series No. 288: The Effect of Sugar Supplements on Dental Caries in Children. By J. D. King, May Mellanby, H. H. Stones and H. N. Green. Pp. viii+55. (London: H.M. Stationery Office, 1955.) 4*s*. net. [294

Murphy Insecticides, Fungicides, Fumigants for Nurserymen. Pp. 124. (Wheathampstead: Murphy Chemical Company, Ltd., 1955.) [29

Department of Scientific and Industrial Research. Report of the Chemistry Research Board, with the Report of the Director of the Chemical Research Laboratory, for the year 1954. Pp. iv+71. (London: H.M. Stationery Office, 1955.) 3*s*. net. [294

Fingerprints: Fifty Years of Injustice. By George Wilton Wilton. Pp. 16. (Galashiels: A. Walker and Son, Ltd., 1955.) 2*s*. [294

British Non-Ferrous Metals Research Association. Thirty-fifth Annual Report, April 1955. Pp. 46. (London: British Non-Ferrous Metals Research Association, 1955.) [294

Institute of Personnel Management. Occasional Papers No. 6: Techniques or Men? Pp. 11. (Originally published in the December 1954 issue of *Personnel Management*.) Pp. 11. 2*s*. Some Principles of Training—Applied to the Retail Trade. By Else Herzberg. (Broadsheet Series.) Pp. 23. 3*s*. 6*d*. (London: Institute of Personnel Management, 1955.) [25

Institute of Seaweed Research. Annual Report for 1954. Pp. 44 (3 plates). (Inveresk, Midlothian: Institute of Seaweed Research, 1955.) [25

Ministry of Education. Report of the Working Party on Grants to Training College Students. Pp. 28. (London: H.M. Stationery Office, 1955.) 1*s*. net. [25

Petroleum Information Bureau. U.K. Petroleum Industry Statistics Relating to Consumption and Refinery Production, 1953 and 1954. Pp. 8. (London: Petroleum Information Bureau, 1955.) [25

Journal of the Chemical Engineering Society of the University of Leeds. Vol. 1, No. 1 (March 1955). Pp. viii+39+1*x*. (Leeds: The University, 1955.) [35

## Other Countries

Chronicle of the World Health Organization. Vol. 9, No. 4: The Work of WHO: 1954—a Review of the Annual Report of the Director-General. Pp. 101–130. (Geneva: World Health Organization; London: H.M. Stationery Office, 1955.) 1*s*. 9*d*.; 0.30 dollars; 1 Swiss franc. [25

United States Department of the Interior: Fish and Wildlife Service. Research Report 36: Noxious Marine Animals of the Central and Western Pacific Ocean. By Charles J. Fish and Mary Curtis Cobb. Pp. iii+45. 35 cents. Statistical Digest 31: Alaska Fishery and Fur-Seal Industries—1951. By Seton H. Thompson. Pp. iv+70. 35 cents. Statistical Digest 32: Propagation and Distribution of Food Fishes for the Calendar Years 1951–1952. By Lee M. Duncan and O. Lloyd Meehean. Pp. ii+36. 20 cents. Statistical Digest 33: Alaska Fishery and Fur-Seal Industries—1952. By Seton H. Thompson. Pp. iv+68. 35 cents. Circular 25: This is a Salmon Hatchery—Producing Salmon to Maintain Commercial and Sport Fisheries. Pp. 8. 5 cents. Circular 27: The Golden Eagle and Its Economic Status. By Lee W. Arnold. Pp. iv+35. 25 cents. Circular 28: A Visit to a Federal Fish Hatchery. Pp. 9. 10 cents. Wildlife Abstracts, 1935–51. (An annotated Bibliography of the Publications abstracted in the Wildlife Review, Nos. 1–66.) Compiled by Neil Hotchkiss. Pp. iv+435. 2 dollars. Conservation in Action. No. 11: Aransas—a National Wildlife Refuge. By Julian A. Howard. Pp. 12. 15 cents. (Washington, D.C.: Government Printing Office, 1954.) [35

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